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JOURNAL
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No. 1.

NOTES ON CORDYLOPHORA LACUSTRIS AND MELI-
CERTA RINGENS.

BY STEPHEN HELM.

(Read November 14th, 1892.)

CORDYLOPHORA LACUSTRIS.—Prof. Allman is, I believe, the only scientist who has investigated the life-history of *C. lacustris*, and although nearly forty years have elapsed since those investigations were made public, they still stand alone. This is attributable in all probability to two causes: first, the exhaustive character of that memoir; and, second, the rarity of the form itself—the former rendering observers shy of entering upon ground already so ably trodden; the latter placing a very effective barrier in the path of those who might have felt inclined to investigate had circumstances favored them.

Notwithstanding this, and the expressive and derisive representation applied to certain persons who “rush in where angels fear to tread,” I am desirous of placing on record some observations made during the past summer, and I venture to hope I may be forgiven for re-introducing this form to the Society after so short an interval.

To make the present remarks clearer I am compelled to refer to my paper published in the April number of the JOURNAL, in which I speak of my anxiety to complete my observations on cer-

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tain new forms therein mentioned, at the earliest possible moment. With that idea I have made repeated visits to the locality in search of specimens, although as yet without result. On one of those visits, that of July 17th, however, I took comfort to my soul, for on peering into the canal I perceived a form which, from its general aspect and enormous numbers, I at once jumped to the conclusion was my long-desired *C. coronata*. But on transferring a colony to one of my bottles for closer examination, to my amazement I found that instead of *C. coronata* I had *C. lacustris*, about the very last form I should have expected. In the paper referred to, on these two forms, I have said that after the most painstaking and diligent search I was only able to find one solitary specimen of *C. lacustris*—and that by accident—amongst the tens of thousands of *C. coronata*. But here I had before me *C. lacustris* enough to supply every microscopist in the world to his heart's content and a few millions of millions over; for although prospecting only on one side of the canal for convenience, it was, for a couple of miles at least, literally lined with it. Wherever there was a resting-place there were the tiny but beautifully branched stems of *C. lacustris*. That I was pleased, nay, delighted, goes without saying, and dreams of a thorough side-by-side comparison of the two forms rose before me, being now sure that, as I had had the good fortune to find *C. lacustris*, I should find *C. coronata* also.

Is there *any unmixed* joy in this world? I pressed the cup of joy—not canal-water—to my lips, but the pleasure was evanescent, being soon embittered by disappointment; for, after two hours' careful search, *C. coronata* was still "conspicuous by its absence." I could not find even one solitary specimen to console me. On reaching home I prepared a tank for my new capture, filling it entirely with the water obtained in this expedition—about a gallon—and looked forward to a grand distribution during the week amongst the members of the New-York Microscopical Society and other friends, even going so far as to make a careful list of those who I knew would value it. Alas! now followed my second disappointment. I had reckoned without my host. The next day my collection looked queer, and I thought it best to defer my distribution. And well it was for my friends I did so. For in three or four days *C. lacustris* was defunct and the water vile enough and black enough for Styx.

Nothing daunted, even though the weather was still very hot, I made another visit. That collection "hurried up" and went bad the following day. Again and again I tried, but, from some inexplicable cause, every gathering went in the same manner, and finally *C. lacustris* went also, gradually disappearing from the canal. I did hope to secure some germs at least, but the only result I to-night have of all these rich hauls, and after some eight or ten visits, is a piece of weed in spirit, which originally carried a few hundred forms, three to six on a stem. This I exhibit to give an idea of the enormous numbers in which it was found.

What investigations I was able to make confirmed a good many of Allman's illustrations. But I found two points of difference, otherwise the Society would have been spared a narration of my experiences.

One point of difference relates to the general position of the tentacula, which were spread in all directions and presented a free, wavy appearance, as in *C. coronata*. As shown by Allman—see April JOURNAL, plate 30—they stand almost vertical, whilst in my "solitary specimen," exhibited November 6th, 1891, they stood out like wires from a telegraph pole. Some few specimens which I was able to retain up to ten days ago had the same free, wavy appearance. Allman's presentation, however, may have been an accidental difference, produced by exceptional environments, and I do not lay much stress upon the point.

But the second point, as to the numbers of the tentacula, seems to me an important one. Allman very strangely omits to specifically state the number of tentacula, except in his description where he says, "Polypi tentaculis numerosis sparsis teretibus," thus leaving it to be inferred that, although numerous, their number is uncertain. And yet in his illustrations, of which he gives four, one, an immature form, is figured with thirteen, whilst of the three matured forms one is figured with twelve and two with thirteen. So that, to say the least, tentacula are "an uncertain quantity." But it is not unfair to Allman to assume that he considered thirteen the maximum number. Now, I found in these captures the tentacula varied in number from ten to twenty, and of these latter so many instances as to convince me that it was not an abnormal number, but quite common. However, that this statement might not go forth on my unsupported testi-

mony, I requested Dr. Pierson, my medical adviser, to count them also, and he confirmed my observations.

To sum up: This experience is certainly one of the strangest I ever passed through. Here is one form—*Cordylophora coronata*, and a new one—existing in countless millions, and for months together, in 1891, disappearing altogether in 1892; whilst the typical form *Cordylophora lacustris*, represented in 1891 by solitary specimens, appeared in 1892 in the same countless millions, but only for a few weeks. Is it possible that in these facts we have an illustration of “alternation of generations”?

MELICERTA RINGENS.—In a contribution to the *Quarterly Journal of Microscopical Science*, Philip Henry Gosse described for the first time the building-up of the tessellated tube of this lovely form of rotifer, which took place under his very eyes. Although nearly every writer on this form since that time quotes more or less from Gosse, I am not aware that any other observer has witnessed the complete operation.

I have felt a desire to do so all my life, and have searched amongst Melicertians hundreds of times, in the hope that I might be so favored, but in vain. At last, on July 26th of this year, I had the ambition of my life gratified. At 10:30 A.M. I perceived a young specimen busily engaged in this interesting occupation. Six rows of pellets had already been completed, and the young builder was still hard at work. I watched this combination of brickmaker, architect, and builder at work for five hours uninterruptedly, which I claim was, for so small and so young an operator, an unparalleled feat even amongst the hard-worked mammals. To be sure, the object, the establishment of a home, and that for a lifetime, was a noble one, and who would not vigorously labor for such a purpose? However, dropping reflections, suffice it to say that at the expiration of these five hours the young artisan rested, evidently considering “the house” high enough for the present, and then proceeded to devote “the wheel of life” to the acquisition of food.

But what had been accomplished in these five hours? Starting with six rows of pellets at the time of first observation, twenty-one rows more were piled up, viz., fourteen rows up to 1:30 P.M., and seven more up to 3:30 P.M. These consisted, as near as I could

count, of twenty-four or twenty-five each on the average, giving a total of over five hundred pellets.

My experience confirmed that of Gosse, that the time occupied in forming a pellet averaged about one minute, for there were short intervals, as you will hear presently. The deposition was accomplished by a sudden jerking of the head, but so rapidly that I could not determine the precise instant of deposit. When we consider that the material for the formation of these pellets had to be gathered from the surrounding medium, in which scarcely a trace could be discovered—literally a case of “making bricks without straw”—it would seem a stupendous effort. All through, the same perfect order in deposition, the same delicately graduated and enlarging diameter, which we are so accustomed to admire in Melicertians, had been maintained—one more proof of the unerring instinct bestowed by the Omniscient Architect on the first Melicertian that ever built its case on these lines, and which had descended through countless generations to the one now before me.

Prof. Williamson says the first rows of these cases are deposited upon a “thin hyaline cylinder, the dilated extremity of which is attached to the supporting object.” Now, with his paper and illustrations before me, I looked very carefully for this cylinder, all through the process of building, but looked in vain. A support of some kind seems essential on which to agglutinate the first pellet, and from it the first caudal row of pellets. For although adhesion to each other by means of the viscous secretion employed can be understood, they would hardly keep in position without some attachment. But, assuming the existence of this “thin hyaline cylinder,” another difficulty arises, that of completing the connection between the tube and the base on which it is designed to finally rest, when the cylinder would manifestly be in the way. Gosse does not mention such a “cylinder,” but the omission is accounted for by the fact that he witnessed the construction from a vertical point of view.

Whilst I entertain the highest regard for Prof. Williamson's paper and for his general erudition, I beg respectfully to say that the after-process I observed leads me to a different conclusion. When I first observed the tiny worker the lowest row of pellets was the $\frac{1}{120}$ of an inch from the base of operations. After three hours' labor in building, this had been reduced one-half. At the

expiration of five hours, and the termination of its labor, the interval had vanished altogether, and the junction of the case with the base to which the animal still adhered by its suctorial disc was complete. It seems to me that a "hyaline tube," on which the first rows of pellets are said to be deposited, must first be constructed, and that when these rows are completed it would have to be got rid of in some way, unless the intervening space were filled up by continuing to build upon it downward, which idea was not warranted by my observations.

The conclusion I am led to is that the first pellet is held in position by a temporary attachment, proceeding from its own body, in some unknown manner, and so situated as not to be in the way when its purpose is accomplished. My theory was produced by observing the singularly beautiful manner in which the tube was brought down. At short intervals the little builder ceased "making bricks," and, suddenly contracting itself upon its adhering tail, pulled the tube down with it for a short distance. By these repeated contractions and efforts the interval was gradually reduced, until the connection with the base was made and the work finished.

We have hitherto been accustomed to account for the tapering construction of the case solely by the different diameters of the body and the tail, but it is possible that a double purpose led to the conception of the design, viz., the lessening of labor in building, and the facilitation of the "pulling-down process" I have described, which latter is no doubt materially aided thereby. Of course it will be asked why the Melicertian does not solve the difficulty by laying the foundations of its tube upon the base on which it finally rests. I simply reply, I don't know. But I also add that, on October 2d, I had the pleasure of seeing another young Melicertian engaged in building, and I also observed the same interval between the caudal end of the tube and the base.

THE CAUSE OF ASIATIC CHOLERA.

BY LOUIS HEITZMANN, M.D.

(Read October 21st, 1892.)

Before Koch's great discovery of the "comma bacillus of cholera Asiatica" many different views were held as to the cause of cholera: first a gas theory, then a miasma theory, a soil theory, and so on, each finding its supporters. In 1884 Koch announced the fact that a "comma bacillus," or rather a "spirillum," found only in the intestines of patients and their discharges, but neither in the blood nor in any other organ, was the sole cause of the disease.

Under the microscope the comma bacillus proves to be a small, somewhat curved rod, in the fresh state often forming long curved threads, and hence its name "spirillum." It is best colored with either fuchsin or methylin blue. Microscopical examinations, however, are not conclusive. A number of other bacteria, such as Finkler and Prior's comma bacillus of cholera morbus, Deneke's comma bacillus found in cheese, Gamaleia's *Vibrio Metschnikoff* found in the intestines of fowls, or Miller's comma bacillus isolated from the mouth, can often not be differentiated, looking almost exactly alike.

Cultures are necessary for an absolutely certain differential diagnosis. Koch has shown that his comma bacillus grows on gelatin in an entirely different manner from that of the other comma bacilli. On the plate small colonies develop in from eighteen to twenty-four hours, which have a pale color, darker in the centre, with a slightly uneven contour, and soon look as if studded with particles of glass. These increase in size, and soon the gelatin commences to liquefy in the centre, forming a small funnel, the gelatin having sunk below the level of the surrounding portions. In a stick culture the same features take place. The funnel in the centre becomes larger and larger, the upper portions apparently becoming filled with an air bubble. The liquefaction of the gelatin goes along slowly, and only by about the sixth day the whole of the upper portion is liquefied.

All other comma bacilli grow differently on gelatin. Finkler

and Prior's liquefies the gelatin very quickly; Deneke's and the *Vibrio Metschnikoff* not quite as fast as Finkler and Prior's, but faster than Koch's; and Miller's not growing at all. Koch's spirillum also grows on agar-agar, milk, serum, potatoes, and, in fact, on almost any cultivating medium, if not too greatly diluted. It needs oxygen, grows best at a temperature between 60° and 105° F., is completely destroyed at a temperature of 140° F. in ten minutes, only grows on neutral or slightly alkaline media, and is soon destroyed by drying.

The last feature shows that it cannot spread through air. It can only act when introduced through the mouth into the stomach. It can be destroyed by sublimate (1:2,000), carbolic acid (half of one per cent), chloride of lime, sulphuric acid, etc. The disease can be prevented with comparative ease. All contact with infected material must be absolutely avoided, and such material thoroughly disinfected. The hands must be kept scrupulously clean, and all water must be boiled before use. The stomach should be kept in good condition, as the comma bacillus will be destroyed in the stomach if the latter performs its functions normally.

PROCEEDINGS.

MEETING OF OCTOBER 7TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-eight persons present.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, dated Houston, Texas, September 29th, 1892, accompanying a donation to the Cabinet of the Society of a slide of pyritized diatoms and foraminifera, as follows:

"I forward a slide of marine diatoms and foraminifera, pyritized, or metamorphosed. They are derived from a stratified clay, at a depth of about thirty feet, in the deepening of the slip in front of the new grain elevator at Galveston, Texas. The natural submarine strata were removed by powerful suction dredges, and discharged in a continuous flow into the adjacent lowlands, with the object of securing deeper water and at the same time of reclaiming a littoral marsh for railroad purposes. In the expul-

sion of the liquid marine mud and sands, numerous large masses of the stratified clay were discharged through the twelve-inch discharge pipes, and an examination *in situ* revealed the presence of the pyritized diatoms and foraminifera. In order to put the interesting occurrence on record, I prepared a selected slide, showing about fifty of the fossilized remains, and this is the only one I had leisure to prepare. With a one-fourth objective and condensed light a pleasant and instructive study may be made of the metamorphism of forms which were once of silicious and calcareous nature.

"Putting this locality upon record extends the known area of distribution for mineralized diatoms. The earlier known specimens were from the London clay basin. Mr. Lewis Woolman's researches in the artesian-well area of the New Jersey coast have extended the subject for that locality. What I have previously put on record with your Society, for the artesian area of Mobile, Ala., has disclosed its further areal extension. And my present contribution from Galveston Bay continues the chain, to be carried on by others interested in the subject.

"I noted the following genera: *Coscinodiscus*, *Actinoptychus*, and *Campylodiscus*, but did not observe a single *Triceratium* in my limited study of the material."

Mr. Cornelius Van Brunt donated to the Cabinet a photographic negative of *Pleurosigma angulatum*, taken with a Natchet immersion, No. 7 lens, by the late Samuel Jackson. Mr. Van Brunt also placed before the Society a cabinet of one hundred and fifty microscopical slides, of the collection of Mr. Jackson, which his family now offered for sale to the Society, and stated that Mr. Jackson was one of the best preparers of microscopical objects, and, until near the time of his death, was one of the most active members of the American Microscopical Society of the City of New York. It was proposed to purchase the collection of slides for the Cabinet of the Society, the expense to be defrayed by subscription.

OBJECTS EXHIBITED.

1. Section of leaf of *Hoya carnosæ*, with crystals of calcium oxalate.
2. Transverse section of stem of *Hoya carnosæ*.
3. Transverse section of petiole of *Aspidestris*.

4. Pipette Filter, for the easy manipulation of hæmatoxylin, anilin green, etc.

Exhibits 1-4 by FRANK D. SKEEL.

5. Codfish, entire, three days old, from the Biological Laboratory at Wood's Holl : by H. W. CALEF.

6. Photomicrograph of the epiderm of the stem of Geranium : by CARL HEITZMANN.

7. Pyritized diatoms, from Galveston, Texas, prepared by K. M. Cunningham : by J. L. ZABRISKIE.

8. Stinging hairs of the larva of *Empretia stimulea* Clemens, the "Saddle-back Caterpillar" : by J. L. ZABRISKIE.

Dr. Skeel stated, concerning his exhibit of *Hoya*, that the plant belongs to the Palm family, and that the sections were stained with anilin green, the fibro-vascular bundles taking the green, while the other structures remain unstained.

Dr. N. L. Britton referred to the great abundance of sclerotic cells in the stem of *Hoya*, and said that Dr. Northrup, using the same stain as Dr. Skeel, was examining this stem near the time of his death, attempting to find the origin and function of these sclerotic cells.

Dr. Skeel also explained the Pipette Filter contrived and exhibited by him.

Mr. F. W. Leggett gave some observations on Paradise Fish reared by him in an aquarium, remarking upon the dissimilarity of the male and female, and upon their quarrelsome disposition.

Dr. Bashford Dean stated that in 1840 a French officer brought home a pair of these fish in an ice-pitcher ; that they are now abundant in the aquaria of Europe ; and that they show most remarkable endurance of foul water and careless treatment.

Dr. Carl Heitzmann explained that the photomicrograph exhibited by him was taken under a power of 1,000 diameters, and illustrated the reticular structure of the protoplasm, and the so-called "intercellular connections" in the stem of Geranium, and continued as follows :

"The reticular structure of animal protoplasm I demonstrated first twenty years ago, although S. Stricker, of Vienna, succeeded two years since in reproducing the reticulum in a living, colorless, coarsely granular blood-corpuscle of a proteus, by means of the electric microscope, with a power of 2,500 diameters. In Ger-

many this fact is not yet generally acknowledged. In this country Dr. Alfred C. Stokes, of Trenton, N. J., has recently described the reticular structure of red blood corpuscles of man after treatment with dilute solution of bichromate of potash, as first discovered by Louis Elsberg twelve years ago. The same author has described the reticular structure in *Pelomyxa*, an amœboid protozoan quite common around Trenton.

"In the speaker's laboratory Mr. Maximilian Toch has studied the structure of vegetable protoplasm for more than a year, and has succeeded in photographing this structure by new methods, which he will soon publish. The specimen exhibited was treated with one-half of one per cent solution of chloride of gold, and afterward with sulphuric acid. The reticulum has assumed a dark violet color, and appears dark in the photograph. In many places numerous delicate spokes are seen traversing the cellulose, or cement substance, interconnecting the reticulum of all so-called 'cells,' and thus rendering the plant a continuous individual, from the tips of the leaves down to the ends of the rootlets. This fact was first established by Louis Elsberg in 1883. The connecting threads are far more numerous than represented by Walter Gardiner, also in 1883.

"Since in the animal organism all so-called 'cells' are of a reticular structure, and all basis and cement substances are pierced by a similar reticulum of living matter, we readily understand the fact that, after liquefaction of the basis substance, its protoplasmic condition is re-established. This happens in inflammation, as proven by the speaker in 1873. Quite recently Prof. Grawitz, of Greifswald, Germany, has rediscovered the appearance of 'cells' in the basis substance of fibrous connective tissue in inflammation, dubbing them 'slumbering cells.' The discovery is twenty years old, and was ignored in Germany for no other reason but that it proved the fallacy of the cell theory and the cellular pathology."

Prof. Edmund B. Wilson, Ph.D., of the Department of Biology, Columbia College, being introduced to the Society by Dr. N. L. Britton, related some observations on the germinal cells of *Amphioxus*: Hans van Vleish, of Zurich, observed with regard to the sea-urchin that, at the two-cell stage of the egg, if these cells were shaken apart, each cell produced an embryo of one-half the

natural size. Last summer Dr. Wilson repeated this experiment in the case of *Amphioxus*. If the two cells are simply disturbed the result will be two embryos; and so, in the four-cell stage, the result will be four embryos, showing an original connection between the cells.

MEETING OF OCTOBER 21ST, 1892.

The Vice-President, Mr. Charles S. Shultz, in the chair.

Forty persons present.

Mr. William Wales was elected Recording Secretary *pro tem*.

The Corresponding Secretary presented a communication from Mr. K. M. Cunningham, accompanying a donation to the Cabinet of two slides of diatoms, and dated Houston, Texas, October 12th, 1892, as follows :

“Notes explanatory of two slides of diatoms :

“1. Slide of *Terpsinoë musica* Ehrbg. On the occasion of a visit to San Antonio, Texas, in the spring of 1887, I secured a specimen of a filamentous alga from the fresh water, flushing ditches permeating the streets of San Antonio. Without knowing what I had secured, I forwarded the material to Mr. C. L. Peticolas, who returned me beautifully prepared slides of *T. musica*, and at the same time solicited a larger quantity of the material. I found it impossible to secure any one who could procure additional material from the same locality. But recently, in August, 1892, while on an excursion to San Antonio, I visited the San Pedro Springs and tested for the presence of *T. musica*. I promptly verified the fact that it grew in the greatest abundance on the water plants choking up the shallow waters of the miniature lake. I secured a rake and landed a mass of *Myriophyllum*, which I allowed to dry in the sun. This I took to Houston, and in a month or more found leisure to make a reduction for the diatoms therein.

“A little acquaintance with the diatoms occurring in this fresh-water lake enables me to tabulate the following species, which may be seen on the slide sent herewith : *Biddulphia lævis*, *Cymbella gastroides*, *C. affinis*, *Cocconeis scutellum*, *Gomphonema capitatum*, *Cymatopleura elliptica*, *Melosira crenulata*, *Navicula nobilis* and others, *Nitzschia panduriformis*, *Synedra ulna*, several species

of *Suriella*, *Stauroneis phænicenteron*, *Terpsinoë musica*. But the slide is characterized by the richness of this last species.

“At least forty years ago Dr. Ehrenberg noted the occurrence of *T. musica* in the rivers of Texas. But only a year ago it was announced in *The Microscope*, under the warrant of a leading New Jersey diatomist in his criticism of a popular article in regard to the distribution of the various genera, that *T. musica* was an exclusively marine genus. This statement met with no denial, so far as I am aware of. The park resort at San Antonio derives its name from the San Pedro Springs, which are bold, fresh-water springs flowing from fissures in a cretaceous, fossiliferous stratum. The flow is so great that it is conducted in bridged ditches, or small canals, through the heart of the city of San Antonio, a mile and one-half distant. The little pleasure lake is, of course, fed by these springs.

“Having placed with the Society two typical representative species or varieties of that American *T. musica*, a field is presented to diatomists to make a comparative study of this genus, with a view of noting the biological divergence between the Mobile River, Ala., marsh deposit of *T. musica*, and the San Antonio *T. musica*. M. J. Tempère, editor of *Le Diatomiste*, Paris, has already in print critically classed the Mobile marsh species as being more nearly related to *T. intermedia* Pantoschek than to the ordinary type of *T. musica* Ehrbg.

“2. The other slide sent herewith is derived from an excavated lake bottom, the result of cutting a canal, or artificial ‘cut-off,’ to reclaim a large area of land subject to periodical inundation, and now to be filled in for railroad station grounds, at Houston, Texas. The lake traversed by the canal once formed a part of White Oak Bayou, and only in the period of high water in the bayou the bayou and lake became coterminous. In low-water periods the lake had a restricted area, containing living mussels, salamanders, etc. Through whatever period the lake may have survived, it became the receptacle for many kinds of microscopic vegetable remains and seeds, as well as a diatom deposit, surrounded on all sides by barren red and white, silicious, sandy strata.

“The slide, while containing hundreds of frustules, was predicated upon the examination of a dry clod of the earth, on the sur-

face of which just one frustule could be made out. At a second visit I found streaks in which the clay partook of the nature of a richer clay, the frustules being easily seen because densely packed.

"The interest in this deposit is somewhat intensified, as the apocryphal '*Navicula craticula*,' or '*Suriella craticula*,' is quite abundant therein, as may be noted on the slide. The other former congeners, *Navicula cuspidata* and *Stauroneis phœnicenteron*, form a majority, which characterizes the slide. Together with these there are species, such as *T. musica*, *Nitzschia circum-suta*, *Cymatopleura elliptica*, *Navicula nobilis*, *N. major*, and a number of other species, as mentioned in the list of San Pedro Springs. Gen. J. D. Cox has investigated the question of *N. craticula*, and, I believe, regarded it at one time as possibly an internal plate or an integral part of *N. cuspidata*, a matter which also interested Dr. D. B. Ward in its solution. He communicated to me, what he regarded as probable at the time, that he had found *N. craticula* in the Montgomery, Ala., fossil, fresh-water earth, where he had not at the time been able to detect *N. cuspidata*.

"Frustules of *N. craticula* occur on the Society's slide, having one-eighth the length of *N. cuspidata*; and likewise frustules of *N. craticula* as large as *N. cuspidata*. The *N. cuspidata* of this deposit are relatively very large and strongly lined, and, side by side with *Stauroneis phœnicenteron*, are very striking under study. Duplicates of either of these slides, in the hands of expert systematists, would furnish data to extend present knowledge or clear up disputed and doubtful points, as the case may be."

The Corresponding Secretary also presented an additional communication from Mr. Cunningham, accompanying a donation of packets of gravel, and dated Houston, Texas, October 14th, 1892, as follows:

"A visitor at Houston, Texas, would be at once impressed by the immense use made of a certain kind of coarse gravel as ballast for the various railroad tracks, and for surfacing the streets of the city; and, if he were a mineralogist, he would at once recognize the presence of petrified wood richly associated with this gravel. In order to place them before the Society, I have made a selection of about a dozen different specimen varieties of these very highly silicified woods. The specimens present some-

thing of structural interest even on casual examination, and they are likewise well adapted to making very fine thin rock sections. This gravel is brought from near Leadbetter, Lee Co., Texas, not far from the Colorado River, and the bulk of the gravel is of a flinty nature, seeming to be of calcareous fossil strata, altered through silicification.

"I have sent, with the fossil wood, a specimen of oölitic and foraminiferal flint, nearly equal in translucency to the chalk flints of the British coast, which can be taken as a type of the flinty gravel of the Colorado River basin.

"In another package I have sent five specimens of a cretaceous or calcareous gravel from San Antonio, Texas, where it is extensively used in the park walks and the pavements around the city. Most of this gravel is in the shape of ovoid or spherical balls, and, if broken in two, are found to be composed of concentric, spherical, concretionary layers, that may be detached continually until the central core, or nucleus, is found. In the specimens sent I have polished each face, to show the peculiar crystalline deposit, from the central nucleus to the outer margin. The two larger pieces are from the one original, and may be fitted together to illustrate the ovoid shape. Inspection suggests that thin sections, when examined with the polariscope, would give concentric radial color effects, which would prove quite interesting. I noticed that children in San Antonio played with them as marbles, using, of course, the roundest that could be found.

"These gravel specimens possibly illustrate a recomposition product of calcareous strata, as in limestone caves, and then, while in solution, redepositing upon some granule or fragment as a nucleus, and gradually augmenting by the same law of calcareous deposition indefinitely, as the balls vary from very small to very large, in the general mass of gravel as distributed. Single and double centres of concretionary action may be noted in the several specimens."

OBJECTS EXHIBITED.

1. *Micrococcus pneumonicus* Friedländer, under a Zeiss one-twelfth homogeneous immersion lens: by CHARLES S. SHULTZ.
2. *Bacillus tuberculosis*, under a Spencer one-tenth homogeneous immersion lens: by CHARLES S. SHULTZ.
3. Comma bacillus, $\times 900$: by LOUIS HEITZMANN.

4. The "S" form of the same, $\times 1,000$: by LOUIS HEITZMANN.

5. Test-tube cultures of the same: by LOUIS HEITZMANN.

6. Slide of mucous membrane of a patient in Calcutta: by L. SCHÖNEY.

7. Photomicrograph of the same: by L. SCHÖNEY.

8. Radial section of the thallus of *Nostoc sphericum* Vauch : by J. L. ZABRISKIE.

9. Living specimens of the same in water: by J. L. ZABRISKIE.

Dr. Louis Heitzmann, of New York, being introduced by the Vice-President, read the paper announced on the programme, entitled "The Cause of Asiatic Cholera." This paper is published in this number of the JOURNAL, page 7.

Dr. George M. Sternberg, of Brooklyn, being introduced by the Vice-President, gave many interesting and valuable points of information on the action and prevention of cholera. He stated, with other items, that the spirillum is quickly killed by desiccation. If little squares of infected blanket are exposed to sunlight two, three, and four hours, it is found that the spirillum will grow after two hours' exposure, but not after four hours' exposure. Sunlight is one of the best disinfectants. In the late operations of the quarantine of our port many articles of clean linen were injured by the steam process, when a little sunlight would have been equally effective. In future operations, doubtless, sunlight would be much employed. With ordinary care nurses of cholera patients do not contract the disease. There is no great danger from germs wafted over in the air from an infected region.

A discussion of the subject also ensued, participated in by Dr. Carl Heitzmann, Dr. Louis Heitzmann, Dr. L. Schöney, Rev. George E. F. Haas, and others.

On motion the thanks of the Society were tendered Dr. Louis Heitzmann and Dr. George M. Sternberg for their interesting addresses.

MEETING OF NOVEMBER 4TH, 1892

The President, Mr. J. D. Hyatt, in the chair.

Twenty-six persons present.

Dr. Arthur Mead Edwards was elected a Corresponding Member of the Society.

The following Committee on Annual Exhibition was appointed by the Chair: Dr. E. G. Love, Dr. F. D. Skeel, Mr. Charles S. Shultz.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, dated Houston, Texas, October 28th, 1892, accompanying the donation of a package of tripoli, as follows:

"I forward to the Society a cabinet specimen of tripoli derived from a superficial outcrop near Navasota, Texas. After having submitted it to a micro-analysis I am able to present the following points of interest in relation thereto. The deposit presents a striking interest geologically, as it appears to be of composite origin, as developed during its analysis. Ninety per cent of the mass may be regarded as made up of what may be alumina in its most highly divided state, or, if not alumina, an amorphous silica, all of which may be completely removed by elutriation. The heavier sediment remaining is found to be volcanic glass, or some like product of igneous fusion, as indicated by its physical characters, viz., complete transparency, flat angular fragments, freedom from admixture with the ordinary silicious, rounded, and abraded grains derived from the decomposition of the azoic or granitic rocks, and whose protean distribution is known to all who have made sands a study. The particles composing this glass are further characterized as being thin plates, filled with vesicles and tubuli, which are very evident in any of the media used in an examination of the same. Examined dry (in air), the vesicles or minute bubbles are very evident, while in balsam they are nearly obliterated. Likewise the tubuli in balsam are differentiated or made quite plain, and finally become indistinct as the balsam invades the air channels of the tubuli; and if the study is made with bisulphide of carbon as a medium, the fragments and plates show with double intensity. (The bisulphide of carbon I refer to is used for patching shoes, and costs ten cents a bottle anywhere, and is called 'quick cement,' and offers a useful medium for the immediate study of diatoms, giving intense and brilliant images before evaporation takes place.)

"If it be admitted that this glass is of volcanic origin, we must necessarily recur to the conditions under which it became a part of this deposit. To do so we are brought face to face with the hypothesis of volcanic dust showers, transported through aerial

currents from distant centres of eruptive activity, and finally settling down on some aqueous area, as a gentle and intermitting rain of mineral particles, during a lengthy period of time. The deposit from which the specimen came is five feet in thickness, and is known to underlie a relatively wide area. Intimately associated with this mineral basis are several kinds of fossil organic microscopic remains, as smooth, non-tubercular, arcuate sponge spicules, crystalline spheres, intermediate in their characters between the polycistinæ and the fossil gemmules of sponges. The spheres have in some instances surface ornamentation of minute bosses, and in others short pyramidal processes or points, giving them a stellate appearance. These spherules had never hitherto been observed by me in any of the many preparations of fossil earths examined. I also saw a few discs, which may be diatoms, but they were unfamiliar shapes to me.

“Touching what has preceded, it is a matter of geological record that in the territory contiguous to the cañons of the Colorado River, and between the Rocky Mountains and Sierra Nevada, there have been observed vast deposits or strata of fresh-water infusorial origin, alternating between beds of volcanic tuffs, lava, and other phenomena of volcanic activity characterizing the struggle between the igneous and aqueous elements for supremacy, in that rock-ribbed region of the earth, now in a state of comparative quiescence. The deposit varies in its composition. Some of the material is as white as chalk and has no admixture of alumina to bind the grains together, and it can be dissipated as dust by dry brushing. When a mount of this is made it shows purely the glassy, angular plates, and nothing else. The economic value of the deposit, either as tripoli or kaolin, has not been overlooked by the commercial instinct, and a sample of the porcelain made from it, and just received from England, shows that it is not adapted to making white porcelain or china-ware, as a cube of it burned into a sort of salmon-colored, translucent glass. A previous trial of it at Pittsburg reported it as unfit for porcelain ware, on account of an oxide of iron that contaminated it.”

On motion the thanks of the Society were tendered Mr. Cunningham for this donation and communication.

Mr. Stephen Helm read the paper announced on the programme,

entitled "Notes on *Cordylophora lacustris* and *Melicerta ringens*." This paper was illustrated by objects under microscopes and by blackboard drawings, and is published in this number of the JOURNAL, page 1.

OBJECTS EXHIBITED.

1. *Octocella libertas* Helm, living : by STEPHEN HELM.
2. *Cordylophora lacustris* Allman, living : by STEPHEN HELM.
3. *Lagotia cæruleus* Helm, living : by STEPHEN HELM.
4. *Lophopus crystallinus*, living : by F. W. DEVOE.
5. Statoblasts of the same : by F. W. DEVOE.

Dr. Romyn Hitchcock, a Corresponding Member, being called upon by the President, gave some reminiscences of the time of his resident membership, and complimented the Society on its vitality and industry.

Mr. F. W. Devoe called attention to the beautiful action of the statoblasts of *Lophopus crystallinus* in his exhibit, revolving inside their gelatinous sacks by means of cilia inserted on the margin of the disc between the anchors.

Dr. F. D. Skeel explained a substage, made for him at his suggestion by the Bausch & Lomb Optical Company, consisting of a plain circular stage with clips, to be inserted at pleasure in the substage ring of the microscope, of great usefulness in operations with low powers, avoiding the extreme racking back of the body and the risk of overturning the instrument.

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The Microscope : Vol. XII., Nos. 9, 10 (September, October, 1892).

The Botanical Gazette : Vol. XVII., Nos. 5—11 (May—November, 1892).

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Bulletin of the Torrey Botanical Club : Vol. XIX., Nos. 9—11 (September—November, 1892).

Insect Life : Vol. V., Nos. 1, 2 (September, November, 1892).

Psyche : Vol. VI., Nos. 198—200 (October—December, 1892).

The Observer : Vol. III., Nos. 10, 11 (October, November, 1892).

Anthony's Photographic Bulletin : Vol. XXIII., Nos. 17—22 (September 10—November 26, 1892).

Cornell University Agricultural Experiment Station : Bulletins Nos. 42—44 (September, October, 1892).

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Agricultural Experiment Station of Iowa : Bulletin No. 17 (May, 1892).

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The Post-Laramie Beds of Middle Park, Colorado; by the author, Whitman Cross (October, 1892).

Journal of the Royal Microscopical Society : 1892, Part 5.

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Le Botaniste : Vol. III., Nos. 2, 3 (August, 1892).

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Wissenschaftlicher Club in Wien : Monatsblätter, Vol. XIII., No. 11—

Vol. XIV., No. 1 (August—October, 1892) ; Ausserordentliche Beilage, Vol. XIV., No. 1 (1892).

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The Weekly Bulletin : Vol. II., Nos. 59—71 (September 3—November 26, 1892).

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No. 2.

SUGGESTIONS IN MICROSCOPICAL TECHNIQUE.

BY ALEXIS A. JULIEN, PH.D.

(Read January 20th, 1893.)

In microscopical investigation of organic structures, success largely depends, sometimes entirely, on their approximately perfect preservation in the form of mounted preparations. In the living organism or a freshly cut slice of tissue, details of the utmost importance may be entirely invisible, which could, however, be clearly brought out only by skilful staining, by patient experiment in search of the most suitable medium for mounting, or by long-continued study under varied methods of illumination or with persistent efforts at resolution, to which only a suitably and permanently mounted object could be subjected. The main object, then, in perfection of permanent mounts, must be, not beauty, nor even the permanent preservation of an interesting object, but, above all, the retention and revelation of its true structure. Unfortunately this has not been the prevailing opinion in all laboratories of investigation; students are often found to have been encouraged or permitted to content themselves, and save time, with some hurried and careless method or step, at a point short of a perfectly completed mount.

The way in which a microscopist finishes, or even merely labels a mount, may often indicate his degree of care and skill in the preced-

ing preparation of the object, and its real value. It is from the point of view, therefore, that no pains can be taken too great for the proper completion of a mount, that the following suggestions are offered on methods devised and mostly in use, for several years past, in the Laboratory of Microbiology of Columbia College, New York. Some of these have been carried over the country by our graduates and so made known to a certain degree, but, to my knowledge, have not been otherwise published.

I. *Carrier of Cover-Impressions.*

In the collection of cover-impressions of various organisms, in the field, such as films of diatoms just spread upon thin covers, desmids, blood corpuscles, pollen, etc., it is sometimes impos-

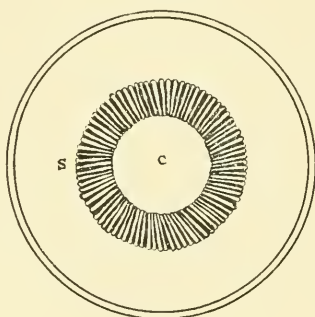


FIG. 1.

sible, while travelling rapidly, to dry the covers and safely pack them up at once for conveyance in small boxes, in the usual way. On one occasion, five years ago, while collecting upon covers the mycoderm-films of certain bacteria and fungi in the hilly country of Western Massachusetts, I felt the need of some convenient apparatus for immediate storage of the covers, while still moist, so that they might be carried with safety, without adherence, abrasion of the film, or breakage. A hint of a convenient method came from a note by F. L. James¹ on a simple cover-glass holder, consisting of a coil of brass spiral spring wire, bent around a groove in a cork, the whole being mounted upon a little wooden stand for laboratory use. This suggested the little carrier here presented (Fig. 1), in which the cork (C), encircled by the

¹ Jour. Roy. Mic. Soc. (1887), 693.

spring (S), is wired to the bottom of a small, round pasteboard box. A thin, loose roll of soft Japanese paper against the inner side of the box prevents the dislodgment of any covers inserted in the coils of the spring; and the box, when closed, can be easily carried in the pocket.

II. *Gas Mounting-Stand.*

In place of the small mounting-table with alcohol lamp, ordinarily used by the microscopist, the little adjustable mounting-stand with gas attachment, here exhibited, has been in use for several years in our laboratory, having been somewhat modified from time to time until it has reached this form. It has the advantage of economy, especially in laboratory use with young students, on account of its tiny gas-jet; it is portable, adjustable, and easily taken apart; convenient in the long retention of heat by the sand-box attached beneath the mounting-plate; and affords support on the ring for small evaporations, or for gentle warming or digestion, when the ring is adjusted over the mounting-plate. A thumb-screw attachment to the arm of the burner, for clamping it to the upright rod, might be convenient, but is easily dispensed with. In the form here shown, the stand has been made for us for some time, both in New York and Philadelphia, and has probably been elsewhere supplied by the manufacturers.

The improvement I have now to present consists in the conversion of the burner, which is often objectionable on account of its smoky flame, into a minute Bunsen burner an inch in length. This is easily accomplished by slipping over the nipple a little tube of brass foil, easily made by any one in a couple of minutes, or, better, of brass tubing, of about six millimetres in diameter, with two small air-holes, on opposite sides, near the bottom, as in a Bunsen burner.

The blue, hot, and clean flame thus obtained is not only best fitted for ordinary heating in microscopical processes, as for burning off the soiled point of a mounting-needle, without soot, but is particularly useful in bacteriological manipulations. Thus, the drying of bacteria-films upon covers is commonly done by passing the thin cover back and forth, three times, through the comparatively huge flame of an ordinary Bunsen burner, at the speed of "a knife cutting bread." In place of this rough method, the

covers are laid by us a certain time, say five seconds, on the mounting-plate, heated at the height of five centimetres above the miniature Bunsen burner with a flame one centimetre in height ; or directly over this flame, at a certain height for a few seconds. The heating in this way is far more uniform than by the common method, the films are well dried but not roasted, and more satisfactory results may be expected in the subsequent staining. What could be a more disproportionate, wasteful, and absurd process than the common one of warming a tiny thin cover, of the size of one's little finger nail, over a rush of flame six or seven inches in height !

III. *Staining-Flask.*

The staining of films which have been dried upon covers, such as bacteria or blood corpuscles, especially when heat is required, often leads, by the common methods, to imperfect or erroneous results in inexperienced hands. Sometimes the stain, after having been heated up in a test-tube, is thrown in a watch-glass, and the cover floated upon it, film downward (Gibbes' method).

The usual method is to hold the cover, with the film uppermost, between the fingers or in a forceps, add a drop or two of the stain, and heat over a low flame until steaming vapors rise from the stain. Though simple, this is troublesome where many films need staining at one time or in succession. There is also a tendency of the stain to dry in an overheated ring around the edge of the cover as well as to deposit granules of color, which, in some cases, adhere firmly to the film and cannot be removed by washing. This is more likely to occur when long heating is needed to stain the object to sufficient depth of color ; the little drop evaporates rapidly, and constant attention is needed to keep it supplied with fresh additions of stain.

In place of these methods, the following simple apparatus has been in satisfactory use in our laboratory for many years. It consists of the following parts :

1. A tight coiled spring (Fig. 2, A), as a cover-holder, in which a large number of thin covers may be clamped by insertion between successive coils. It is made from a spring of fine brass, copper, or steel wire, not coarser than No. 26 gauge, wound on a one quarter inch mandrel. It is best made from fine platinum

wire, of the usual gauge for blowpipe-work, its temper having been removed before the winding, and restored afterward by quick annealing, plunging while red-hot into cold water. The wire at one end of the coil is bent into a little loop for suspension. After long continued use, the platinum wire has the special advantage of being easily purified and retempered by heating to red heat and again plunging in cold water.

2. A small, wide mouthed flask (Fig. 2, B) to hold the staining-solution. This may have a capacity of about forty cubic centi-

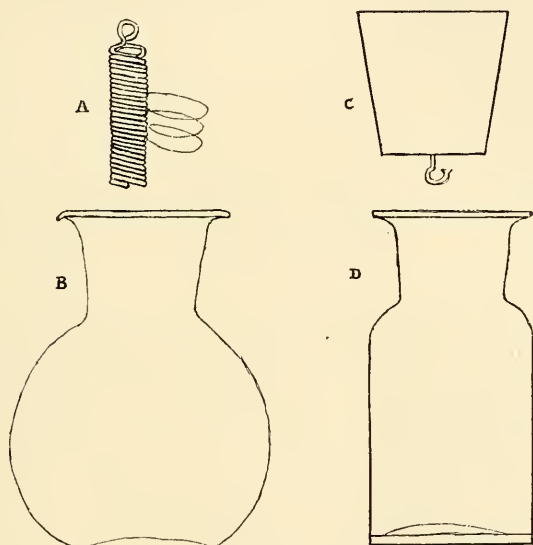


FIG. 2.

metres, with an aperture at the mouth of at least two centimetres. To this a wide cork (Fig. 2, C) is somewhat loosely fitted, on the under side of which is stuck a pin bent into hook-form, from which the coil A may be hung. This flask, when in use, is kept about two-thirds filled with the desired staining-solution.

3. A wide mouthed, glass-stoppered bottle (Fig. 2, D), of the same aperture as the flask, to hold the second solution, which is often required, as a mordant.

For example, in the staining of bacteria-films dried upon covers, the flask B will receive the solution of campechian or other stain, and the bottle D the mordant solution of sodium

chromate or tannin ; or, in Löffler's method, B the hot mordant, and D the colorant. The covers are to be first firmly inserted in the coil with the help of a knife-blade, with the films downward, and so suspended from the cork. In the campechian staining method, the stain in the flask is previously brought up to the boiling point by holding it a few minutes over a flame. The cork is then inserted, making sure that the covers remain entirely immersed in the hot stain. The apparatus is left upon a mounting-table, so heated as to keep the liquid very near or just below the boiling point, and there allowed to remain for the length of time desired in any particular case, which may even be an hour or more. A large number of covers may be thus stained at one time, with little needed attention. The cork is finally lifted out of the flask, and the coil, without removal of the covers, is plunged into successive beakers of distilled water until the covers are thoroughly washed from excess of stain. Then the glass stopper is removed from the bottle and replaced by the cork, so that the coil with its burden of covers now remains plunged in the mordant for the requisite time.

It may be added that the staining-flask is useful as well in many cases where there is call for long and slow staining of films on covers in a cold solution. The handling of thin covers in mass, by this method, rather than individually, is found to diminish greatly their liability to breakage.

IV. *Condensed Air-Film.*

We have next to consider a long neglected source of the air-bubbles which form a constant annoyance to the working microscopist. At times they may only indicate the content of air originally dissolved in the cold preservative, expelled by warming it, and likely to be entirely reabsorbed in the course of time, after the cooling of the mount. Frequent instances of this occur, especially in the use of warmed glycerin jelly, melted Canada balsam, and dammar. More commonly they may be derived from entanglement with the fibres of a filamentous object, enclosure in the pores or empty cells of a cellular object, or simply from mechanical attachment to the cell-wall or to the cover, overlooked in hasty mounting without sufficient use of the pocket lens. Their neglect in such instances may injure the appearance of a mount and inter-

ferre with observation, by the coalescence of several minute fixed bubbles into a large movable one. This may lead to harm by weakening the mount, disturbing the object as the bubble rolls about, and tending to foster germ-life for its destruction.

In cases, however, of extreme care toward their avoidance, the experienced microscopist has been repeatedly surprised and disgusted by the mysterious appearance of minute air-bubbles, in a hermetically sealed mount, from some unknown source. To that source I would call attention, in the film of condensed air and moisture which has been shown to be firmly attached, under ordinary conditions, to the surface of all solid bodies, and which has been best studied on the surface of metal and glass.

The following precautions are taken in our laboratory against this invisible enemy :

1. As the air-film can be removed by friction, all plain slides and the interior of cells are briskly rubbed just before using. The microscopist unfamiliar with the difficulty would content himself by merely dusting an apparently clean slide.

2. The stock of glass covers is thoroughly cleaned at one time by immersion in Seiler's solution (one part saturated solution of potassium dichromate in three parts of concentrated sulphuric acid) for about an hour, thorough washing successively in common and then in distilled water, and immersion in strong alcohol. In the latter the covers are allowed to remain, in a wide mouthed glass-stoppered bottle of about thirty cubic centimetres capacity. Just before use each cover is taken out and well rubbed, dried, and placed on a warm mounting-table, so that it may be applied to the mount chemically and microscopically clean and entirely devoid of the air-film, which ordinarily soon becomes condensed upon a cold glass cover.

3. All preservatives are kept slightly warmed just before use, and the object is soaked in distilled water recently boiled and cooled, and therefore strongly absorbent of air.

The insertion of a mount in a vacuum, under the bell-jar of a convenient air-pump, for a short time just before it is to be covered, is a useful precaution, especially with an object consisting of more or less tangled fibres, or of a cellular character with partially empty cavities. But I have not found that the condensed air-film can be removed in that way.

V. *Supply Can for Sterilized Non-aërated Water.*

A little flask, fitted as a wash-bottle, will usually suffice to supply a small quantity of water, recently boiled, cooled, and free from dissolved air.

But when there is need of a less fragile apparatus for more constant or larger supply, and, especially in bacteriological research, it is desirable to have at hand a reservoir of sterilized water, the following apparatus will be of service. A cylindrical can (Fig. 3), made of copper or tin, and of any desired capacity, is covered with a tightly fitting cap, which can be removed for cleaning the

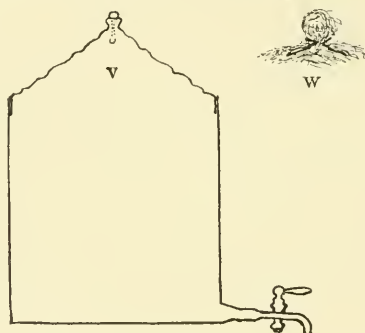


FIG. 3.

interior. In the centre of the cap an automatic escape-valve (V) for steam is inserted. From the side of the can, at the bottom, a supply-pipe runs out a few inches horizontally, ending in a faucet. The can, thoroughly cleaned and scalded out, is nearly filled with distilled water and heated over a burner to boiling, for a couple of hours. While the steam is actively escaping from the valve, a wad of sterilized cotton (W) is quickly wrapped about the valve, and the burner removed. The wad is fastened with a turn of a piece of wire, and a cone of filter paper thrust over the end of the supply-pipe, to protect it from dust. When sterilized water is needed, the paper cone is removed, the end of the pipe flamed, and the faucet turned.

VI. *Mounting Medium for Algæ and Fungi.*

The microscopic objects and structures which receive the at-

tention of the naturalist are constituted, in by far the largest number of cases, of formed, non-contractile material. Even delicate tissues consist, in large part, of sacs, sheaths, or other envelopes enclosing protoplasm or sarcode, but themselves constituted of formed material, such as cellulose, chitin, etc., able to resist heat or partial desiccation or dehydration without much distortion. For the numerous objects of this vastly predominant class many good mounting media have been found. Their sheaths, carapaces, and skeletons being tough and stout enough to resist most of the tendency to distortion produced by the contraction of the minutely divided protoplasm they contain, the processes and the preservatives employed answer a useful purpose. By selective absorption of stains, or by exceedingly delicate contractions or expansions effected by treatment with acids, absorbents of water, etc., particular details of organic structure become peculiarly colored, swollen, or shrunk, and so rendered prominent by contrast and more easily distinguishable. Most histological preparations, for example, by their vari-colored tissues, intensified nuclei, etc., serve to convey supposed or established facts from one observer to others. For such purpose, these methods are legitimate and most useful, but may be, and generally are, just as artificial as those of drawing and photography for the true representation of structure.

But, on the other hand, for the permanent preservation of living contractile matter, without immediate or ultimate contraction and distortion, such as the protoplasmic contents of thin walled cells of fresh-water algæ, water fungi, bacteria, rhizopods, infusorians, etc., no satisfactory medium has yet been found. This is an entirely different problem from that above considered, and for its solution the elements of the higher tissues, with their minute subdivision of contractile matter in granules and cylinders often less than ten microns in diameter, afford too diminutive a field for exact microscopic discrimination of effects produced by various processes and reagents.

But he who attempts to preserve an object like *amœba*, the cell contents of a *desmid* or *spirogyra*, bacteria in *zoöglœa*, etc., cannot deceive himself in regard to his limited degree of success, as he notices the contracting contour of the comparatively huge mass of protoplasm. Only an object of this class, however, can

serve for a sufficiently delicate test of minute movements in the outline of the protoplasm itself, which, in ordinary objects and in tissue sections, might entirely escape observation.

It is surely possible to predicate and classify the main causes to which must be due the shrinking or swelling, distortion and disintegration, which, sooner or later, are seen in progress within the cells of most mounted preparations of organic material. Thence we may deduce certain principles of selection or exclusion, which we may apply toward the various reagents, mixtures, and solvents which claim fitness for this service. The careful synthesis of formulæ according to this system ought to clear out of our way, once for all, a large number of unsuitable reagents; to put a stop to the concoction of merely experimental formulæ; and to bring us much sooner into possession of satisfactory processes. It is now proposed to offer a brief statement of the chief causes of alteration of organic structures, when immersed in so-called fixing and hardening solutions and preservatives.

1. *Alteration by Change of Natural Conditions or by Death.*—When we attempt to watch and unravel the lovely phenomena of life thrilling and pulsating within the field of the microscope, great care and skill are needed to preserve those natural conditions, within which it is possible, even in the living organism, to recognize the normal forms and relationships of its structure. By any change of temperature, produced by the heat of the room or lamp, or the coldness of the metal of the stand; by lack or excess of moisture, oxygen, or light; by vibration or jar; by offensive vapors in the atmosphere, carbon dioxide gas from the observer's breath, or the volatile solvents that are kept or used in the laboratory; and perhaps by still more subtle but efficient causes of disturbance, morbid and unnatural changes in the contractile matter may be produced which are difficult or impossible to avoid.

But artificial trial by means of chemicals, as fixatives and stains, by dissection and vivisection, however useful or indispensable for study of special elements, tends to be still more fatal to accurate discrimination of protoplasmic forms in general morphology.

And, for this purpose, death ends all; instantaneous coagulation and alteration ensue; our slow recognition of cadaveric

changes is due only to the imperfection of our apparatus and methods. Even the special absorption of certain stains by the living protoplasm of plants and animals is almost always attended with extreme irritation and then their death by poisoning; it is not yet safe to assume that such a death is not accompanied by morbid change, however imperceptible hitherto, in many cases, by our best skill in observation.

Partial success, it is true, has been obtained by the use of paralyzing reagents, such as cocain; but in general, as Hofer observes, "a simultaneous swelling of the protoplasm occurs, so that, although the topographical conditions are retained, the histological details are in many cases destroyed."

A general acknowledgment of the fact, therefore, that a mounted preparation, however useful as an accessory source or illustration of special facts, can only be a mummy, or a slice of a mummy, never a satisfactory substitute for the living protoplasm of the original tissue or organism, would have a tendency to clear the air of much controversial vapor, our literature of interminable discussion, and our life work of a vast amount of wasted labor. It seems at first discouraging, but I think it is true.

The partial success in the past, however, leads us to hope that, by more systematically devised processes and formulæ, we may succeed in arresting protoplasmic changes so speedily and thoroughly, as to cause the organisms embalmed in our cells to retain a far more life-like approximation to their original structure. To this end, precaution must be taken to guard against the causes of distortion yet to be considered.

2. *Contraction by Chemical Reaction.*—The jelly-like contents of the cells may be diminished by slow solution or by chemical reactions gradually produced through some constituent of the surrounding medium. Alcohol, in any proportion, should therefore be omitted, on account of its known solvent action upon chlorophyll and other coloring matters; its dilution signifies only delay in solvent attack. Any acid, moreover, especially if inorganic (with a few exceptions, like carbon dioxide), has a tendency to produce contraction; this apparently consists of actual disintegration and destruction of sarcode in time, particularly rapid in that of protozoa, amœba, and the cœlenterata. This tendency may be very useful in bringing out certain structures

by development of contrast. Of this common examples are found in the use of acetic or chromic acid in differentiation of nuclear structure ; of picric acid in direct staining of tissues ; of osmic acid in fixation of tissues, and in coloration of fat through deoxidation. But there is every reason to believe that the protoplasmic elements, in the tissues or organisms so accentuated or colored, no more remain in their original condition than, for example, the threads of muscular fibre teased out with needles by a laboratory student for the purpose of more easy distinction. In this connection we may remark the significant change of opinion¹ of such authorities as Berthold, Schwartz, Kölliker, and others, on the subject of the true structure of protoplasm, who now look upon the reticulum and fibrils, recognized by Frommann, Arnold, and others in sections of tissues so treated, as being only artificial products.

All these acids, then, together with their salts, such as ammonium and potassium dichromates, and mixtures like Müller's fluid, Erlicki's fluid, Lang's solution, etc., need to be rejected for our present purpose. The only ones likely to be found useful, in high dilution, are such organic acids as exist in living tissues, possibly such as oxalic, malic, citric, etc., in plants, and sarcodic, lactic, butyric, etc., in animals. As a rule, the mounting medium for which we are now searching should probably be neutral in its reaction, for most objects.

This conclusion condemns at once and altogether, for preservation of protoplasmic forms, the use of the resinous media, so excellent for general purposes of mounting—Canada balsam (so often the refuge of the lazy microscopist, wishing to avoid the construction of a cell), gum dammar, copaiba, copal, and styrax. The objection to these is founded not only on their slight content of organic acids, as well as of turpentine or similar solvent, but also on the complicated series of processes required for the preliminary dehydration and subsequent clearing. A glance at the evidences of tedious torture of protoplasm in these long-drawn-out processes ought to be sufficient to account easily for their failure in the permanent preservation, without distortion, of the natural forms of contractile matter within the interior of cells.

We have also to guard against the shrinking of living proto-

¹ O. Bütschli, *Sep. Abd. Verh. Deutsch. Zool. Gesell.*, 1891, 14-20.

plasm in the presence of corrosive agents (in some cases, perhaps, this shrinking inside of a cell-wall being the only movement it has shown in life), as well as that due to "irritability," even after death. The irritating properties of the gold and platinum chlorides, and the strong astringent properties of the alums, on which is founded their usefulness in media for other purposes, are particularly objectionable, in my opinion, on account of the corresponding contraction they produce upon protoplasm. Therefore, for this purpose, I am inclined to reject King's fluid for marine algæ (alum, mercuric chloride, and sea water); Wickersheimer's preservative for algæ, lichens, fungi, etc. (alum, common salt, potassium nitrate, potassium carbonate, arsenious acid, distilled water, glycerin, and methyl alcohol); an alga preservative (chloroform, glacial acetic acid, and distilled water); Pacini's preservative for blood corpuscles (mercuric chloride, common salt, glycerin, and distilled water); Morehouse's preservative for algæ, desmids, volvox, etc. (copper acetate, camphor water, distilled water, glacial acetic acid, and glycerin); Meckel's, for protozoa (chromic acid, acetic acid, platinum chloride, and water); preservative for algæ, characeæ, and infusoria (salicylic acid, wood vinegar, glycerin, and water); preservative for confervæ (chloroform, glacial acetic acid, and water); Ripart's preservative for spirogyra and other algæ (glacial acetic acid, camphor water, and distilled water); preservative for algæ, desmids, etc. (Deane's compound, Ralf's liquid, glycerin jelly, and solution of aluminum acetate); preservative for entomostraca (carbolic acid, alcohol, and water); Goadby's preservative; boroglyceride (boracic acid in glycerin); and a large number of others.

3. *Contraction by Absorption of Water.*—This cuts off at once, it seems to me, the use of all the dehydrating fixatives, hardening solutions and preservatives, *e.g.*, those in whose composition either alcohol or glycerin has been used in any proportion whatever. The fact that some such mixtures have seemed at least comparatively satisfactory to investigators probably shows only that contraction has progressed more slowly and distortion been longer deferred. With half the percentage of the ingredient that is greedy for water, the mounted object is ruined in two years instead of one.

Notwithstanding the recent recommendation of Klein¹ for the

¹ Jour. Roy. Mic. Soc. (1883), 140, from Hečwigia.

preservation of the fresh-water algæ, this is the main objection to the use of pure or diluted glycerin, glycerin and camphor water, camphor water and alcohol, glycerin jelly, Farrant's and Bulloch's media (*i.e.*, mixtures of gum arabic and glycerin), etc. The same objection may probably hold to the more complicated mixtures, such as Heintzsch's preservative for desmids, algæ, etc. (alcohol, glycerin, and distilled water), Hervey's preservative for marine algæ (glycerin and sea-water), etc

4. *Contraction, or, it may be, Irregular Expansion, produced by Osmotic Action through the Cell Wall.*—A most efficient cause of alteration in shape of the colloidal masses inside of the wall must probably lie in this interchange of liquid and soluble matters with the medium outside. The greater the difference in density (commonly aimed at for the sake of contrast in refractive index, with corresponding improvement in definition), as when the external preservative is nearly pure water (*e.g.*, camphor water), or in solubility, as when the preservative is a strong saline solution, the more active the osmosis and the more speedy the deformation. We may consequently expect that solutions of common salt, potassium acetate, aluminum acetate, calcium chloride, etc., and the large number of preservatives made up of complex combinations of sundry salts, must be specially objectionable in this way, where protoplasm forms are concerned; so also, perhaps, even syrup, honey, dextrin, and solutions of gums, to some degree.

5. *Contraction by Heat.*—The more delicate forms of protoplasm, even after death, are commonly sensitive to very slight elevations of temperature. This presents one serious objection to the use of hot glycerin jelly, aside from that founded on the absorption of water by its content of glycerin.

It is, of course, still more efficient for harm in the resinous media, like balsam and dammar, and many others of higher refractive index in which heat is used, such as sulphur and arsenious acid, realgar, etc.

We may, therefore, conclude that any medium requiring a temperature much above 30° C. (say 85° F.) for sufficient fluidity is unfitted for the preservation of protoplasm.

6. *Disintegration by Bacteria and Minute Infusorians.*—In many or most cases a living object, plant or animal, when about to be immersed in the fixing or hardening solution and the pre-

servative, is already covered with myriads of these destructive agents, either mature or in the condition of gonidia, spores, or eggs. In mounts from hands inexperienced in regard to this danger, one can find, long after the preparation was made, an abundance of living forms, particularly bacteria, which must be preying upon the mounted object. To meet this attack some suitable and permanent germicide should be added in proper quantity as a constituent of the preservative.

Mercuric chloride (corrosive sublimate), often used for this purpose, should be avoided, in my opinion, on account of its unstable character, as it gradually loses chlorine and separates from solution in the form of particles of calomel, feebly antiseptic if at all; also on account of its corrosive nature, which tends to disintegrate most forms of sarcode.

Most acids, like carbolic (phenol and thymol), salicylic, picric, boracic, arsenious, chromic, etc., are equally unsuitable, on account of their corrosive nature and acid reaction. Camphor may be of little permanent value, on account of its slight solubility in water solution—*e.g.*, in the form of "camphor water"—and also its ready absorption by organic matter of the walls of the mounting cells.

As to chloral hydrate, there is increasing evidence as to its possession of antiseptic power, as well as tendency to preservation of chlorophyll and coloring matters; while the satisfaction of its affinity for water by a single molecule insures the absence of farther dehydrating power.

There are also several copper salts which seem to possess the same desirable qualities as chloral, especially the chloride and nitrate, and the principal objection to the acetate appears to be its instability.

In our own Laboratory experience, after trial of a large variety of the preservatives in common use, we have found Petit's solution apparently the most satisfactory for the preservation of fresh-water algæ and even colored fungi, with longest retention of both form and color in the protoplasmic contents of their cells. This conclusion is founded on an examination of several hundred mounted preparations of these objects during a period of about fifteen years past. The following is the well known modification¹ of Ripart's published formula :

¹ Internat. Jour. Micr. and Nat. Sci., 3 ser., ii. (1891), 177.

Copper chloride (crystallized).....	0.2 gm.
Copper nitrate “.....	0.2 “
Glacial acetic acid	0.5 “
Camphor water... ..	50 c c.
Distilled water.....	50 c.c.
Shake up until solution, and filter.	

After some time, however, we found it advisable not to use this solution in its full strength, but with the addition of an equal bulk of boiled distilled water. More recently two further modifications of the formula have suggested themselves. First, the glacial acetic acid should be omitted. Secondly, as the two copper salts, even in the chemically pure form supplied in commerce, have ordinarily an acid reaction, the free acids should be neutralized in some way.

It should also be remarked that the nature of protoplasm itself varies so greatly, as to constitution, density, color, transparency, contractility, and other properties, that it is not at all probable that a single preservative of universal application can ever be devised, even for the forms of vegetable protoplasm.

The desirable qualities, in a mounting medium suited to preserve aggregates of protoplasm in their original form, size, and color, as seen within the organic cell, are the following :

Neutral reaction ; absence of dehydrating power ; density approaching that of protoplasm ; fluidity below 30° C. ; content of efficient germicide ; and very low or very high refractive index. Where, then, can we find this ideal preservative medium for protoplasm ? Only hitherto, I think, in the dreams of the hopeful naturalist.

In my own Laboratory our attention has been largely given to the preservation of the fresh-water algæ and water fungi. From former experience we have hopes of success from the following preservatives, now on trial.

A. *Organisms with delicate walls and rather thin and watery endoplasm* (e.g., desmids, beggiatoa, etc.).— A tiny grain of naphthalin is inserted, part way but firmly, into the inner side of the cell-wall (paraffin or wax), and only the filtered native or mother water of the organism (or boiled and cooled distilled water) is used to fill the cell. In this we hope to have a substitute for camphor water, with a more efficient and permanent germicide.

B. *Organisms with endoplasm of ordinary density* (e.g., most of the filamentous algæ).—This is a solution founded on experience with Petit's preservative :

Copper chloride.....	0.1 gm.
Copper nitrate.....	0.1 "
Chloral hydrate.....	0.5 "
Distilled water, just boiled.....	100 c.c.

From this solution, however, the trace of acidity must be removed in this way: Another solution is prepared of a few grammes of any soluble copper salt ; to this a weak solution of caustic potassa is added in slight excess ; the precipitate of hydrated copper oxide (CuH_2O_2) thus obtained is washed thoroughly, first by decantation and then upon a filter. This purified residue is then thrown into the one hundred cubic centimetres of preservative first prepared, and the whole frequently shaken at intervals until a neutral reaction is shown by test papers, and then filtered.

C. *Organisms with Apparently Dense Endoplasm*.—To one hundred cubic centimetres of Solution B add ten grammes of gum arabic, in selected white grains, shake until solution, and filter. Possibly gelatin may be found preferable to gum arabic. The object of thickening the solution is to prevent any tendency to osmosis ; though, of course, the approximation of refractive index within and without the organism may tend to decrease the definition.

VII. *Balsam-Paraffin for Cells.*

The materials commonly used for cell construction, though of excellent application, particularly shellac varnish, gold size, Bell's cement, copal varnish, and zinc cement, are open to two objections.

1. The freshly spun cells can only be used after baking or drying, which may require considerable length of time. This sometimes stretches into weeks or months in the case of gold size, where the process of ripening is mainly one of oxidation.

2. The material, even after thorough drying, is gradually soluble or liable to softening under the action of some of the constituents of common preservatives, particularly alcohol and inorganic acids.

In 1880 we began the use of paraffin for spun cells, and it has

been used continuously ever since in our laboratories. Its decided neutral reaction or indifference toward most chemical reagents renders this a unique material for a cell-wall, from a chemical point of view. It is but slightly soluble in alcohol, though freely in ether, benzol, xylol, and turpentine. It is miscible with fixed or volatile oils when melted, and, I believe, slowly when cold. Fortunately its strong solvents are rarely or never employed in the constitution of preservatives.

The fitness of paraffin for cell-making has repeatedly occurred to microscopists at home and abroad. A few years ago a suggestion of its use for cells was published in a German scientific journal; and more recently it has been recommended by F. N. Pease¹ simply for ringing balsam mounts.

Nevertheless its use appears still to be limited, if not unknown, in many laboratories, and no reference is made to it in the last edition, by Dallinger, of Carpenter's work on "The Microscope." This has been caused, I think, by its insufficient adherence to glass. Early in its use we found this defect indicated, at times, by the inability of a liquid mount in a paraffin cell to bear moderate pressure without easy rupture, generally at the bottom of the cell, next the slide. Paraffin, in cooling, does not form a homogeneous solid, but a congeries of crystals, often comparatively coarse. Its deficiency seemed to call for the addition of some substance of greater adhesive power, whose diffused particles would also serve as nuclei to induce the consolidation of the paraffin in a more minutely crystallized mass. This was easily accomplished by previously saturating the paraffin with one of the strongest cements, balsam-cement; the result has proved entirely satisfactory after use for nearly ten years. The following are the details of the simple method. A supply of balsam-cement is first prepared by slow evaporation of commercial Canada balsam, in a shallow tin pan, over a low flame, until the point is reached of wax-like consistence on cooling, as tested on drops removed and cooled from time to time.

For the paraffin the hardest variety in commerce is used, with highest melting point, above 45° C. (113° F.). After the stock of this (say one-quarter of a pound) has been heated over a low

¹ *Micr. Bull.*, vii. (1890), 1.

flame to the melting point, a small lump (say nut size) of the balsam-cement is added, and the whole digested at gentle heat, with frequent stirring, for about an hour, until the saturation of the paraffin by balsam is shown by a slight yellowish tinge. This colored paraffin contains less than five per cent. of balsam and is now ready for use; a supply is poured into a shallow porcelain capsule with broad bottom, of about thirty cubic centimetres capacity. When needed, this is heated upon the mounting-table over a very low flame and kept just at the melting point. Overheating should be avoided, indicated by the escape of vapors, as it tends to break up the paraffin into softer forms and also to volatilize the diffused balsam-cement. At long intervals it may be desirable to add a little more of the original hard stock to the capsule, and a very small lump of balsam-cement. A common camel's-hair brush (extra sup. No. 2) is used to transfer the paraffin, and, on account of the low melting point (63° C.), the brush needs no cleaning after use, and, if not allowed to remain too often in contact with the hot bottom of the capsule, it lasts almost indefinitely. In use, the turn table should be placed as near as possible to the capsule, and, if convenient, on the same level. The glass slides on which the cells are to be spun should also be kept warmed upon the mounting-table. If very shallow cells are needed, mere films, suitable for mounting bacteria in potassium acetate, the slides should be hot, and even a slight warming of the turn-table may be of advantage if the room should be cold. Cells may be thus spun at a single twirl of the brush, shallow or deep, in proportion to the load of paraffin on the brush and the mode of its application.

A paraffin cell is immediately ready for use after it is spun; this is one great advantage of the material over all others. Paraffin cells spun in this way are well suited for dry mounts, as they are free from moisture and do not give off the oily vapors whose condensation, in cells made from sheet wax, has been found in time to obscure the under surface of covers.

In using a paraffin cell for a mount with a liquid preservative, the first step is to flatten the top of the cell, which, if the cell is deep, is apt to be convex. This can be done with a stroke of a fine flat file, taking care to remove any loose particles which might be thrown into the cell. This flattened surface

should be then moistened with a mere film of liquid marine glue; the object and preservative then introduced; the cover applied and pressed down into contact with the sticky film of glue; the excess of preservative which has exuded cleaned away with rolled bits of absorbent paper; and a thin seal of paraffin then spun around the joint between the cover and the cell. Both to strengthen the seal, to protect the paraffin with a hard coat, and for appearance, a thin coat of some finish is then spun over the whole surface of the paraffin. This may be colored according to taste, such as red sealing-wax varnish or black asphalt; but in our laboratory a colorless finish is preferred, imparting a porcelain glaze to the cell, such as gold size, liquid marine glue, King's colorless cement, rubber cement, etc. With a paraffin cell one may thus finish the entire mount at once, without the necessity of waiting at any point for cell or seal to dry.

A limitation of the use of paraffin cells lies in the necessary avoidance of oils as preservatives, as in the case of mounting crystals in kerosene or castor oil; for this a cell of shellac varnish or King's cement is best suited. Nor can liquid Canada balsam or gum dammar be used with safety in a paraffin cell, on account of the attack of the turpentine, as a ready solvent of the paraffin wall.

Colored varieties of balsam-paraffin are also of use, especially black, white, and blue, made, respectively, by intermixture with lampblack, with zinc oxide, and with Prussian blue, each thoroughly dried and carefully sifted through a fine lawn sieve. Heavy powders, like white lead and vermilion, cannot be well used, on account of rapid settling to the bottom of the melted paraffin. Even with the three colors above mentioned, the mixture in the capsule must be rapidly stirred just before the brush is loaded.

Only cells of some thickness can thus be made from colored paraffin; but, when the mount has been finally varnished with one of the finishes already stated, the black paraffin assumes a jet-like glaze, and the zinc paraffin a white enamel of great beauty. The latter seems preferable to zinc cement, on account of its uniformity, constant insolubility and impermeability toward most preservatives.

Of course, in the use of paraffin mounts with a projection microscope, the insertion of the alum-cell is desirable, to prevent ele-

vation of the temperature of the slide to a degree near the low melting-point of paraffin.

The balsam-paraffin is well suited for making deep cells by means of the Chapman mould, either in the simple form or colored, *i.e.*, the black or the white zinc paraffin. Two precautions need attention :

1. The mould should be kept well cleaned, and its inner surface rubbed over with a very slight film of vaselin previous to use. This prevents the adherence of the paraffin cell, which comes out readily in perfect form.

2. On account of the low melting point of paraffin, it is difficult, in the ordinary way, to cause the moulded cell to adhere perfectly to the warmed slide, without partial fusion and injury. A paraffin film should be first spun upon the slide, carefully warmed just to the point of fusion, the moulded cell applied, and the whole quickly cooled.

INAUGURAL ADDRESS

BY THE PRESIDENT, MR. CHARLES S. SHULTZ.

(Delivered January 20th, 1893.)

It is with much misgiving that I now assume the duties and the honor of the Presidency of this Society. Do not expect me to reach the high scientific standard of the gentleman whose successor I have become, nor the standard of those who have preceded him in the office. I desire, however, that faithfulness and energy may make partial amends for possible lack of talent.

May I then, at the outset, trouble you with a few suggestions which, if heeded, may be of some service to the Society ?

Let us be punctual, so that the meetings may be opened at the appointed hour. Let exertion be made to attend all meetings, whether papers are announced or not. Meetings with unannounced papers or addresses have usually afforded the attendants much pleasure and instruction. Also, a numerous representation infuses a spirit of emulation on the part of those in attendance, and greater results are consequently obtained. Encourage the

attendance of ladies, and thereby increase the social features of our gatherings. To most of you now present the request to attend is superfluous, as you have appeared here with regularity and may be expected to do so in the future. We have, however, numerous members, and among them some of our ablest thinkers, who seldom grace these rooms with their presence, although they occasionally make amends by an excellent paper or address. Should the last-mentioned class appear more frequently, the Society's work would be greatly enhanced, while it would be the means of bringing others here, who would discuss the papers and participate in extending the desirable work now sustained by the faithful few.

Exhibitions of apparatus and demonstrations of manipulation are exceedingly desirable. Even if there is not anything absolutely novel in such presentations, there are doubtless many, not yet adepts, who would thankfully receive the instruction. The expected address this evening by Dr. Julien on "Microscopical Technique," together with the novel apparatus now displayed before us, gives hopes that the influence of this session will be a valuable incentive to the holding of many future "working sessions." Work of this nature was frequently accomplished at the earlier meetings of this Society, the incidents of which our older members will recall with delight.

Let more objects be brought for exhibition. Announcement of these on the programmes is urgently requested. But let not inability to make timely announcement prevent the desired exhibition. In this manner we have frequently received valuable instruction from those engaged in special research, and in the preparation and mounting of special classes of objects.

There are those, whose time is not entirely taken up by their regular avocations, who might derive much pleasure themselves, and be of great service to others, if they would undertake the examination of foods, food products, drugs, textile and other fabrics, with the view of the detection of adulterations and admixtures. In conjunction with a friend, who is an analytical chemist, I have recently had occasion to critically examine white writing papers. In the course of our investigation we have discovered, among other things, that much of the fine paper, water-marked "pure linen paper," is more or less mixed with cotton and other

materials. Upon this subject I may in future give you some particulars.

Let us remember that photomicrography, and the various results, in the form of prints and lantern slides, are always welcome themes that may be demonstrated at the meetings, and that would be received with pleasure by the members generally. I also request that those engaged in the lines of histology, pathology, and bacteriology bring before us from time to time, as Dr. Heitzmann proposes to do at the next meeting, notice of their work in papers on these subjects, which we guarantee will be received with deep attention.

I will not burden you with further suggestions at present. If I shall accomplish nothing more, in the future I will endeavor to infuse enthusiasm in some of our friends who are able to present their good works before you. If each of us will at least add a little toward the general interest, much usefulness and enjoyment will doubtless result, to the benefit of the Society, whose prosperity we all have at heart.

PROCEEDINGS.

MEETING OF NOVEMBER 18TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Eleven persons present.

A communication was received from the New York Camera Club inviting the Society to attend an exhibition of the Heliochromoscope, by Mr. Frederick E. Ives, of Philadelphia, to be given at the rooms of the Club on the evening of the 21st instant.

On motion the thanks of the Society were tendered the New York Camera Club for this invitation.

OBJECTS EXHIBITED.

1. Living Spider, held in a lace cage, showing circulation of the blood in the legs : by F. W. DEVOE.
2. Crystals of Platinocyanide of Yttrium : by E. G. LOVE.
3. Cyclosis in *Chara*, showing remarkably good circulation : by J. D. HYATT.

4. Spherometer, made by the Geneva Optical Company, of Chicago : by F. D. SKEEL.

5. Musical Rasps of the grasshopper, *Conocephalus ensiger* Harris : by J. L. ZABRISKIE.

Mr. Devoe explained the construction of his lace cage for holding small living insects while under observation. The top and bottom are removed from an ordinary paper pill box. The rings, forming the body and the lid of the box, are each covered with a piece of fine lace, kept tightly stretched by having the edges glued down on the outside, and in such manner that, when the lid is placed in its natural position on the body of the box, the two pieces of lace are brought into contact. A small insect placed between the two pieces of lace can be held firmly and yet without injury in any position, and can be examined on the stage of the microscope by either transmitted or reflected light.

Mr. Zabriskie exhibited a female, and the green and brown forms respectively of the male of *Conocephalus ensiger*, and stated, concerning the musical rasps, that in this species, as is common in the green grasshoppers and katydids, the rasp of the left wing cover is much more prominently developed than that of the right. In the slide exhibited the left rasp has eighty teeth, while the right rasp has only fifty-seven. A brown male kept in captivity sang vigorously on the evening of September 30th last. The wing covers were raised very slightly, but were shuffled with extreme rapidity, causing one long note. One such song, timed by the watch, was sustained loudly and continuously, without the slightest break, for the space of four minutes and twenty-five seconds.

Dr. Skeel explained the mechanism and operation of the spherometer exhibited by him.

MEETING OF DECEMBER 2D, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-two persons present.

The President delivered an address on "The Origin and Formation of the New York Microscopical Society." He read from the original copy of the call for the first meeting of the Society, dated November 12th, 1877 ; from the original copy of the constitution and by-laws, adopted December 21st, 1877 ; and from the minutes of the first six meetings. These papers were lately de-

livered by the first Secretary, Dr. Romyn Hitchcock, to Mr. Hyatt, who was the first President, being elected on December 11th, 1877, and they were now transmitted by the latter to the Society. Mr. Hyatt in most interesting manner referred to the enthusiasm and work of the early years of the Society, and especially to the efforts made in 1878, finally crowned with success through the good offices of Hon. J. D. Cox, then Congressman from Ohio, to induce the Government to rescind the postal regulations excluding glass slides from the mails.

Mr. William Wales followed this address with reminiscences of the American Microscopical Society of New York City; of the report of the committee on the examination of the vertical illuminator invented by Prof. Hamilton L. Smith; of the persistent search by Dr. Rufus King Brown for the lines of *Amphipectura pellucida*; and of the manufacture by himself, in 1868, of the $\frac{1}{30}$ objective for the Army Medical Museum, which lens lay for ten years in the table draw of Surgeon-General Woodward, but which finally produced the photograph which first showed the resolution of the famous diatom.

The following Committee on Nominations of Officers was appointed by the chair: J. L. Zabriskie, William Wales, F. W. Devoe.

OBJECTS EXHIBITED.

1. Fragment of brown wrapping paper bleached by carbolic acid: by F. W. LEGGETT.

2. Musical Rasps of the Round-winged Katydid, *Amblycorypha rotundifolia* Scudder: by F. W. DEVOE.

3. Section of Lapis-lazuli: by J. D. HYATT.

4. Section of milky Quartz: by J. D. HYATT.

Mr. Leggett explained that the paper exhibited by him was originally of a deep, dirty yellow color, but by the action of the acid it bleached entirely white. This was followed by a discussion on the action of carbolic acid and of peroxide of hydrogen, participated in by Messrs. Ashby, Skeel, Riederer, and Zabriskie.

Mr. Hyatt remarked that the difference between milky and transparent quartz was mainly like the difference between consolidated snow and clear ice, depending upon the preponderance of the inclusions of air, giving the white appearance.

MEETING OF DECEMBER 16TH, 1892.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-two persons present.

The Committee on Nominations, appointed at the last meeting, reported their nominations of officers for the coming year, and the report was adopted.

The Corresponding Secretary read a communication addressed to Mr. Charles F. Cox, by Mr. Frank B. Carter, of Montclair, N. J., offering to the Society the rare opportunity of purchasing sets of slides of the Radiolaria obtained from the material collected by the "Challenger Expedition," prepared and now for sale by Prof. Haeckel, of Germany.

Dr. F. D. Skeel read an article in the *Medical Record*, issued this day on Photomicrography by Dr. Robert M. Fuller, and exhibited numerous photomicrographs, and also photographic views of the apparatus by which they were taken.

OBJECTS EXHIBITED.

1. Section of tabular Quartz from Thomaston, Georgia: by JAMES WALKER.

2. Section of rock-mass, formed by the pressure of the explosive in the bottom of a drill hole: by JAMES WALKER.

3. Transverse section of the stem of *Helianthus annuus*: by F. D. SKEEL.

4. Transverse section of the stem of *Sassafras officinale*: by F. D. SKEEL.

5. Satin leaf from Cape Town, Africa: by F. W. DEVOE.

6. Section of oölitic Chert from England: by J. D. HYATT.

7. Tulip wood, in natural condition, showing tracheids and medullary rays: by T. B. BRIGGS.

MEETING OF JANUARY 6th, 1893.

The President, Mr. J. D. Hyatt, in the chair.

Twenty-two persons present.

The Treasurer and the Librarian presented their annual reports, and the reports were adopted.

The President appointed Messrs. William E. Damon and F. W. Leggett tellers of the election. At the closing of the polls

the following persons were declared elected officers of the Society for the year 1893:

President, Charles S. Shultz.
Vice-President, Edw. G. Love.
Recording Secretary, George E. Ashby.
Corresponding Secretary, J. L. Zabiiskie.
Treasurer, James Walker.
Librarian, Ludwig Riederer.
Curator, George E. Ashby.
Auditors { F. W. Devoe.
 { W. E. Damon.
 { F. W. Leggett.

The retiring President, Mr. J. D. Hyatt, delivered the Annual Address, entitled "Hints of Intelligence in the Movements of Plants." The address was discussed by Messrs. C. Van Brunt, W. J. Lloyd, Rev. G. E. F. Haas, and Drs. Carl Heitzmann and N. L. Britton.

Dr. Carl Heitzmann exhibited a photomicrograph of the endosperm of the Ivory Nut, and remarked upon it as follows:

"It is a curious coincidence that, while the President dwells on the puzzle of the movements of plants, I hold the solution of the puzzle in my hand. It is a photomicrograph made by Mr. Maximilian Toch. The object is a section through the ivory nut, or vegetable ivory, prepared by a method peculiar to Mr. Toch, and to be published by him in due time.

"In an address last May I showed in this Society a photomicrograph by S. Stricker, of Vienna, illustrating the reticular structure of living protoplasm, discovered by myself twenty years ago, and now accepted even by French histologists, as proven by a letter published by Dr. Alfred C. Stokes in the last number of *Science*. What the French term 'hyaloplasma' I have designated as the *living or contractile matter*, and their 'paraplasma' with me is a lifeless liquid filling the meshes of the reticulum. The same features, in a meeting of last October, I demonstrated to be present in the protoplasm of plants, and I showed the delicate, thread-like connections piercing the cement or cellulose, which I have claimed to be formations of living matter, uniting the reticulum in the protoplasm of our so-called 'cell' with that of all neighbors, thus rendering the plant an uninterrupted con-

tinuity of living matter—one individual—and not made up of millions of individuals, as the cell theory had suggested.

“My present photograph demonstrates the interconnection of the protoplasm by threads of living matter traversing the bulky layers of the so-called ‘sclerotic cells’ of the ivory plant, to perfection, with a power not exceeding five hundred and twenty-five diameters. Even the hardest wood, therefore, is not only supplied with protoplasm, but is rendered a continuous mass of living or contractile matter.

“A peripheral irritation of this substance in certain plants will suffice to produce its contraction, either locally in the leaves or petals, or throughout the whole plant. What we call nervous action is probably based altogether on the contraction of the living matter which, running centripetally, is termed ‘neuraction,’ and running centrifugally leads to motion in the apparatus termed ‘muscles.’ Motion is again nothing but contraction of the heavy masses of living matter stored up in the muscles.

“The contraction of the living matter is all that is needed for the understanding of the peculiar ‘intellectual’ movements of plants, which are destitute of both nerves and muscles. The voluntary actions, even in the highly-developed animals, are only automatic.”

MEETING OF JANUARY 20TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons present.

Dr. H. G. Piffard was elected a resident member of the Society.

The following were appointed by the chair as Committee on Admissions: F. W. Devoe, William E. Damon, George F. Kunz, William Wales, F. D. Skeel.

The following were appointed Committee on Publications: J. L. Zabriskie, William G. De Witt, Walter H. Mead, John L. Wall, Charles F. Cox.

Dr. Alexis A. Julien read the announced paper, entitled “Suggestions in Microscopical Technique.” This paper was illustrated by the exhibition of many pieces of apparatus, and is published in this number of the JOURNAL, page 23.

Dr. Carl Heitzmann replied to certain statements of Dr. Julien, on the uses of acid preservatives, as follows:

“The essayist has spoken rather slightly of certain acids and their dilute solutions as preservative fluids. Still there is nothing better for the preservation of both animal and vegetable tissues than a half of one per cent solution of chromic acid. Sections through any portion of the plants will be preserved, without noticeable change, by being dipped into the named solution for one or two hours. The most delicate animal tissues, such as chick embryos, from the very beginning of development, can be preserved by being kept first in a one-tenth of one per cent solution of chromic acid, gradually being transferred to stronger solutions, never exceeding one-half of one per cent.

“The brain, spinal cord, the eyeball, and especially the retina are best preserved in Müller’s fluid, consisting of one per cent bichromate of potash, two per cent sulphate of soda, and ninety-seven per cent distilled water. This fluid preserves admirably, though it hardens but slowly. Alcohol may be in turn resorted to for the latter purpose. The preservation in alcohol alone is objectionable for microscopical purposes, on account of pronounced shrinkage and abstraction of color.

“Another excellent preservative fluid is a one to two per cent solution of osmic acid, which keeps the minutest structural features unchanged, even in the most delicate (nerve) tissues of animal organisms. Theo. Eimer, of Tübingen, has succeeded in preserving, by means of osmic acid solutions, even the most minute structures of jelly-fish, transferred directly from sea water to the solution. I have specimens of the retina and the spinal cord of man and rabbit, perfectly preserved by osmic acid solution for a number of years.

“As regards mounting media, I concur with the essayist in the statement that we are lacking perfection. The worst used is Canada balsam, strictly objectionable because clearing up the specimens far too much. For the last twenty years I have used nothing but chemically pure glycerin of Merck in Darmstadt, Germany, which, though expensive, yields excellent results. Of course great skill is needed for finding the proper amount of glycerin to fill the space between slide and cover glass. The slightest surplus, oozing forth at the borders of the cover glass, must be re-

moved carefully with moist filtering paper, lest the varnish used for sealing together the glasses peel off after a few years. Glycerin jelly has not answered our expectations, since it renders the specimens blurred.

"For sealing I use nothing but asphalt dissolved in spirits of turpentine. Although black and not looking handsome, this dries within twenty-four hours, and keeps unchanged for a number of years, provided that even the slightest film of glycerin has been carefully removed around the edges of the covering glass. Pretty sealing, although very pleasant to the eye, I consider superfluous."

OBJECTS EXHIBITED.

1. Many pieces of apparatus explained in the paper as above : by A. A. JULIEN.
2. Insect in amber : by F. D. SKEEL.
3. Sections of antenna of the Wasp, *Vespa maculata* L. : by L. RIEDERER.
4. Zentmayer Centennial Stand, with large aluminum stage and certain improvements : by WILLIAM WALES.

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SOME PHENOMENA IN EXUVIATION BY THE
REPTILES.

BY SAMUEL LOCKWOOD, PH.D.

(Read May 19th, 1893.)

In a run through Europe I saw upon a peasant boy clothing that had come down from an ancestor. The garment seemed defiant of wear, but it was painfully malodorous. In nature it is a law for every living thing that the old covering shall give place, at some pretty regular period, to a new raiment. It is similar in principle, whether it be the shedding of the bark of a tree, or the moulting of the feathers of a bird, or the casting of the hard encasement of a crab, or the soft skin of a snake. For this, if the condition is normal, each has its period for laying aside the old and appearing in the new. In the human subject the operation is continuous. I have been surprised, by actual test, at the amount of dermal epithelia floating in the air of a school room, due to the friction from the natural activity of childhood.

Some animals have periodic castings, when the entire outer skin is shed, and the creature then appears in brighter attire. When this process is entire, science, through Huxley, I believe, has given to it the term *exuviation*.

In what will be said on this subject, in the term Reptilia I

shall follow the older meaning, as when it included the Amphibia or Batrachia, simply, however, for convenience.

I recall with what interest, then a young man, the late distinguished palæontologist, B. F. Meek, told me of his witnessing near Albany an old toad taking off his shirt and then swallowing it. He narrated the fact to James Hall, the geologist, who seemed almost incredulous. Since then the spectacle has been seen by a number of naturalists. The sight is truly comical. *Bufo*, when the time for undressing comes, has his own difficulties, suggesting his need of a valet. The batrachian head is a very immobile thing, much as if it were soldered to the shoulders; for one can hardly say that a frog or a toad has any neck at all. By certain contortions of the creature the skin is caused to crack. The limbs are brought, one at a time, to the mouth, and so the denuding is at last accomplished. The old garment is now badly torn. As the funniest part of the play should come last, so it is now, for *Bufo* begins a quasi rolling-up process with his cast-off linen, literally tucking it into the mouth, alternately with his right and his left hand. It is at last got into the chest, with as much regard for order as when the husband does the packing of the wife's trunk.

The toad loves the land, but the frog gives much of its life to the still waters; hence the former affords better opportunities for observation when shedding. Like the toad, the frog divests its cuticle in tatters, and devours it, although a contrary statement may be found in the books.

It is a puzzle to divine what may be the significance of this eating its own skin by the reptile. If a stalk of corn be returned to the ground the cuticle gives up a silicate and a phosphate for vegetable alimentation. Is there in the toad's case some conservation of alimentary chemistry? In a day when exact science was not yet born there seems to have been a belief that an extraordinary virtue resided in a cast-off, dirty shirt; for, said a Dr. Van Helmont, "if you put into a vessel a few grains of corn, and stuff into it a dirty shirt, after about twenty-one days the ferment from the dirty shirt, modified by the odor of the corn, effects the transformation of the wheat into full-grown mice." Of course, whatever the marines may do, sailors won't believe that yarn. But the skin of the toad has in it a virtue of a different nature—

the ability to exude an acrid liquid for its defence. It is amusing to note the experience of a dog on his first acquaintance with the creature. If rash enough to seize it in his mouth, the animal will drop it with grotesque expressions of surprise. Perhaps this acrid liquid is a condiment to the cast-off skin, so that what is pungent to Ponto's nose may be piquant to Bufo's tongue. The frog, which is more aquatic, utilizes its skin to aid the lungs in respiration. Thus its cuticle plays an important rôle in the absorption of oxygen from the water, and perhaps the air, and in the evolution of carbonic acid gas.

The true frogs and toads are called *Anourians*, meaning the tailless frogs; for they dispense with this appendage soon after leaving the larval life. They do not, however, drop it or cast it off, but literally take it in. They begin their adult career as severe economists. Sitting on the shore, having for the first time ventured from their watery home, they enter on a veritable newness of life. Each now is a lung-breather. His tail, otherwise useless, is his pabulum for the nonce. This appendage is absorbed—that is, taken into the assimilation, literally eaten, as truly as in his coming days his cast-off cuticle will be taken in.¹

But there is another branch of this Batrachian gens—the *Urodelia*, the tailed frogs. Such are the efts, the newts, and the salamanders, which retain their tails through life. Thanks to that little eft, the crimson-spotted Triton, which takes so kindly to the aquarium, the act of exuviation may be often witnessed. This Triton, the *Diemyctilus viridescens*, as it seems to me, sheds its skin with an irregular periodicity, doubtless due to food and temperature. Living in the water, it is much easier for these creatures to doff their old clothes than for those animals which do it on the land. When the cuticle has become effete, which in the Tritons is very thin, a little muscular exertion will cause it to stretch, and so admit the water between it and the body, when some wriggling movements will cast it off. It will leave the limbs like tiny gloves, the very toes being preserved in form. Thus this filmy thing floats in mid-water, expanded even to the toes. If we could suppose the tiniest efts doing laundry work, we might liken it to a garment on a clothes line and inflated with the wind.

It must be a canon of Urodelian propriety, for the little Triton

¹ See note at end.

proceeds to tuck the cast-off vestment into his chest. But this is not allowed by his two companions, so each one seizes a limb. And now all three are pulling on the filmy thing, which in consequence gets put away into three chests instead of one.

It is noticeable how much brighter the colors are after exuviation. The crimson spots are very pronounced and the bronzy green has more of a living hue.

In some stained mounts of the Tiger Triton, *Amblystoma tigrinum*, kindly lent me by Rev. J. E. Peters, the cells generally showed distinct nuclei. Although feeling my ignorance of their significance, I would venture to remark: the *Urodela* shed their skin quite often, at least several times in the season. A person told me that he had seen the Red Triton (*Spelerpes ruber*) in an aquarium shed every month. He may possibly have exaggerated. But would not the known frequency indicate a high-growing or vegetative activity in the cuticle? And has not the nucleated cell a higher vital energy than that one whose protoplasm is all simple or homogeneous? Hence this earlier maturing of the Triton's epiderm. So it is here as with the plants—the more rapid the growth the sooner the effete stage is reached.

Leaving these Batrachians, we now come to the Lacertilians, or true lizards, the highest in rank of the Reptilia. Here, too, we find this shedding of the skin, from the great Monitor of the Nile to the little pine lizard that runs on the fence.

I will first instance the so-called Horned Toad, the *Phrynosoma*, which is a true lizard and no toad at all. The sharp-pointed and spike-like projecting scales, which give to the innocent little thing so formidable an aspect, make exuviation of the cuticle in anything like large patches impossible. And so, excepting from the abdomen, which has none of these sharp projections, the cuticle is divested in small pieces and deliberately stowed away.

I wish here to narrate what was witnessed by a friend in the Great Plains. The incident has a psychological interest, and, as will appear, a physiological bearing on our subject. Owing to its sluggishness in captivity the *Phrynosoma* is generally regarded as an utterly stupid creature. My friend saw a female with her young, for which she manifested a striking maternal regard. Alarmed by his presence, she put forth persistent efforts

to get her little ones out of danger by sidling first against one, then against another, until she had them all pushed into a rut of the road. Here the little mother with her young squatted so that they were nearly flat. Had it been a sand bed they would have burrowed out of sight. In this instance the effort was to get out of observation—a quite different thing. In color like the soil, with the tint a little intensified by emotion, they were apparently mere excrescences of the ground.

As the chromic mimicry of the *Phrynosoma* is confined chiefly to one color, I shall speak of it as a monochrome, in distinction from the chameleon, whose mimic power of color is very marked and so is to be called a polychrome. We know that soils in some regions maintain a preponderating color over a large area. It is an interesting fact that *Phrynosomas* of the same species have the one fixed color corresponding to that of their natal soil. As I understand it, the pigment cells, or, literally, color tubes, of the chameleon are of several kinds and deeply seated in the true derm or nether skin. I have under the microscope a mount of the cast skin of the horned toad, *P. cornutum*. It is composed of semi-transparent spaces, erroneously called scales, which, however, is a convenient term. Each of these spaces is bordered by a very much thicker cuticle. The whole is suggestive of a window sash, the transparent parts being the panes and their thick borders the lattice-work. In this thin tissue, more or less crowded to one side of each pane, may be seen the brown pigment granules. They are of one predominating hue and of great quantity, being in the cuticle, while the specimen of cast cuticle of *Anolis* now under the microscope shows no pigment grains whatever. In *Anolis principalis* the panes, as I have called the thin parts of the scales, are much thinner and more transparent, serving, as I conceive, their function for a window through which the color changes can appear when the pigment of the under derm is brought up against them.

I think we may regard the true or under skin of *Anolis* functionally as a palette, in which the different colors are like collapsible tubes set side by side, the tints being produced by pushing the colors against this window of almost membranous tissue, for to such I have likened the transparent vestment. Suppose a mosaic of microscopic discs or hexagons of more colors than one

set side by side, say yellow and blue. The effect would be green, and as perfect to the eye as if these two pigments were mingled on a painter's palette. Thus I think we find a constitution in these two specimens of exuviated lizard skin which stands in physiological relation to the animal's mimetic functions, in *Phrynosoma* as a monochrome and the superficial situation of the pigment, and in *Anolis* as a polychrome with the deeper location of the color cells.

One of my Anoles long outlived the others, getting to know us, and even to take flies from our fingers. We called him Nolie. When awake, especially if he were active, the color was a sombre gray or brown; but if taking a siesta he would put on a suit of green. In his night sleep this would be often a frosted pea-green, very rich, having a sort of bloom not unlike that of oxidized bronze. The Anoles belong to the family Iguanida, and, like the large Iguanas, they have a fold under the throat, which, though imperceptible for the most part, can be suddenly developed into a dewlap of large size and of flaming color. I have seen Nolie wake from sleep, perhaps from an amatory dream, for he would assume his gayest courting suit, a vivid green, with here and there a tint of orange, and in some places the green would be nearly blue, and that improvised dewlap in blazing scarlet—a cravat perfectly stunning for color and dimensions. Indeed, the suddenness of the development and the intensity of the color were simply remarkable. One day he got out of his cage, and a prolonged search failed to find him. But when the night set in that whitish-green gave him away, it was in such marked contrast with the rung of the black-walnut chair to which, almost flattened out, he was adhering sound asleep. Here certainly mimicry was all at fault. As my hand seized him the green flashed out and the normal brown took its place.

It was well no worse thing happened to our pet, for in the shock of sudden fright these little lizards sometimes dislocate their tails. "This is owing to a thin, unossified, transverse septum which traverses each vertebra," the vertebra breaking easily through this brittle plane. A very near cousin to *Anolis* is our New Jersey Pine Lizard.¹ This pretty little thing will sometimes get on the door sill in the pines, and should the good housewife take the

¹ *Sceloporus undulatus* (Harlan), one of the "Tree Swifts."

broom the little swift darts off, occasionally leaving its tail. I have been assured by an old woman "that it does this so it can run faster, but that if the tail is let alone it will come back at night and put it on again." I once had an *Anolis* get out of a box containing several when I was travelling in a rail car. As it was on the floor of the car, my movements in its capture had to be quick and almost violent. This entailed disaster, for the runaway was returned to his companions minus his tail. In about three months the lost member was replaced by a new one. This curious condition ensued. While all the rest of the body was polychromatic, the tail was a simple monochrome. It could not take on any hue other than its one normal brown. Nature had restored the tail, but she could not duplicate "the true inwardness" of the lost member. The palette of living colors and the muscular system for the collapsible tubes were wanting. The little fellow would go to sleep in his night robe of green, but that tail was always the one sober brown.

The cast-off skin of the *Anolis* is a pure, gauzy white, and to the unaided eye not unlike lace in structure, but in fineness far beyond the possibility of any human fabric. But under the microscope this delicate tissue displays a beautiful complexity of structure. The lattice-work is not so coarse as in *Phrynosoma*, and each window pane seems to be made up of irregular lesser panes, and these with extremely delicate lattices. The panes, too, are very thin and clear, with no pigment granules.

Exuviation is started at the head generally, although I have seen instances where the skin began cracking first in other parts. Having got broken at the head, which presents the appearance of a very ragged and highly starched night cap, the rent proceeds along the neck and back. As the *Anolis* is a lithe and extremely agile creature, it can undress with facility, for its mouth can reach any part of the body and detach the loose skin. It doffs the old suit in a very leisurely way, stopping to swallow each piece as soon as it is detached. Nor does it gulp down the cuticular morsel, but eats it slowly, not unlike the refined epicure who gives his food the sauce of gustatory contemplation. Strange, too—exuviation of the new tail is less facile than was that of the old one.

We have left the *Ophidia*, or serpents, for the last. From the

huge Boas and Pythons down to the little snake met with in a rural walk, each and all without exception shed the skin, and, as a rule, cast it whole if the animal is in a healthy condition. It is observable, too, that these reptiles have no polychrome power whatever. The green snake while in the grass finds its color protective, but the reverse when upon the naked soil or crossing the white lichen patches in the pines. The scales of fishes are distinctly different from the true skin, as our nails differ from our skin. Let us repeat that, as with the reptiles already considered, the scales of serpents are simply thickened dermal tissue, over which is spread the true epiderm or thin scarf skin.

Now, having found in the woods just where its owner left it a good specimen of a cast snake skin, four interesting facts may be observed: (*a*) It is shed entire and in one piece. (*b*) It is untorn, except about the head. (*c*) It is turned inside out, as a long stocking might be. (*d*) And fourthly, even the very eyes have moulted, the thin scarf even in shedding preserving their form perfectly in inverted relief.

As to the way in which serpent exuviation is accomplished, the popular idea, and generally even that of the books, is simply this: "when the moulting time has come the animal draws itself between two objects, anything that will suffice for a purchase, such as sticks and stones, and thus manages to rub off its skin."

To such a notion the simplest reasoning upon common observation must demur. At time of shedding the scarf is very moist, and as frail almost as tissue paper. If a lady could have full-length arm gloves of as thin and frail a tissue, it would be impossible for her maid to remove one by any process of friction or rubbing down without tearing them into fragments. And even if the tissue could resist such treatment, would it be possible that they would thus come off turned completely inside out? Then, as to the serpent's eyes, since they must be moulted too, could such friction do less than injure them? Moreover, the places in which these exuviæ are found are not consonant with this friction hypothesis. For they are quite often found on the plain soil, where there are no objects that could be used for friction; and even the ground where the moult is left hardly shows signs of movement.

Having witnessed the operation in very favorable circum-

stances, I gave an account of it to the *American Naturalist*, January, 1875, and also in *Nature*, November, 1879. The serpent, in fact, is the only creature that can denude itself with the peculiar results which have just been mentioned. The anatomy and physiology of the animal are singularly fitted for the operation. The ophidian eye is immobile. Though the books speak of the serpent's eyelids, it is simply accommodating language, for it has no true eyelid. Citing P. Martin Duncan in substance, the so-called eyelid of the serpent is an immovable covering of three superposed layers. First, there is the outer one, the epiderm, which is moulted; this is elastic, and is the thickest over the middle of the eye, manifestly for protection. Under this is the second or middle membrane, which is very delicate and soft, and at the centre perfectly transparent. Under this is the third layer, a mucous lining. This is functionally the palpebral lubricant. Thus the outer covering of the eye is really a part of the scarf, extending from the snout to the end of the tail.

In an old Boa or Python are over two hundred pairs of ribs. These begin immediately back of the atlas or first vertebra and extend to the beginning of the tail—that is, where the dorsal vertebræ end and the caudal series begins. The abdomen of a snake is covered with transverse parallel scales, or scutes. These, when set on edge and acted upon by the ribs, become a vast mechanism of motor propulsion. For this purpose the ribs are all functional. A pair of serpent's ribs form almost a circle, and can perform a fore and aft movement, and can be operative through the circumference of the body except immediately in the dorsal region. We shall see that the ribs have all to do with the act of exuviation. It is hardly a figure of speech to say, as will be shown, that with his ribs the serpent creeps out of his old clothes.

In the pines of New Jersey is a fine colubrine serpent, the *Ptyphis melanoleucus*. I have kept these for years in my study, and will give substantially a paragraph from my article already referred to as in the *American Naturalist*. It describes the exuviation of the Pine Snake as I witnessed it on the floor of my library: When I first saw it I noticed that the skin at the snout was torn, and that denudation had proceeded from the head to some two inches of the neck. The divesting at first glance had a sort of

rolling aspect. What surprised me was the fact that there was not the least friction in the process—that is, there was no rubbing against any object. As the old skin at this time is moist and a little elastic, any swelling of the body stretches and loosens it. So soon as the exuviating reaches the body, where are the larger ribs, the process goes on rapidly and with a singular system. It is done in this way : Exactly at the place where the skin seems to be moving backward a pair of ribs expands. This action swells or enlarges the body at that place, and thus by slightly stretching loosens the skin there. In this movement both ribs in the pair engaged act together—that is, they expand at the same time. This action is instantly followed by a second movement, very different from the first. One rib of the pair, say the one at the right side, slips out of and forward of the constriction just made by the swelling. The advanced rib is then drawn backward with a jerk against the neck of the old skin. The rib then rests, holding this side of the skin backward. The left rib advances, and repeats for its side the action which has taken place on the right side. Thus the action of the ribs, which at first is together, is now alternate. The next hinder pair of ribs now takes up these movements. So close are these consecutive actions, and so rapid, that, while the entire body does not make any perceptible advance on the ground, it seems, at the places where the ribs are acting, to be crawling tremulously out of a double tube.

It is noteworthy that unless the philosophy of the process be considered, whether it be the eating or the undressing of the serpent, the eyes of the observer will be deceived. One smiles at the man who said “he never felt so good as when he had got himself outside a beefsteak.” Now, this “getting outside” is a literal fact as respects the serpent with its prey. By a hitching on and pulling upon its victim with each side of the mouth alternately, the body is actually drawn over the prey. So is it with this action of the ribs in exuviation. Apparently it is a pushing the old garment backward, while really it is a pushing or advancing of the body forward. The old hose evolves from itself forward, though it seems to be rolling on itself backward.

Herein is revealed how it is that a serpent is at the finish of an exuviation practically where it was at the beginning of the process. The ribs forward of the pair which is acting on the skin are oc-

cupied, each pair with its own abdominal scute, which has a purchase or hold on the ground; hence the curious fact that, however long a serpent may be, it comes out of its skin without much forward movement of its body. When the tail is reached this peculiar play of the ribs is wanting to act upon the skin. But the caudal tapering makes the shedding easier, as, in fact, the skin can then be shaken off. As the end of the tail of the Pine Snake is a hollow spike, this, for obvious reasons, cannot be turned inside out, so it is left turned inside of the skin, all else being turned inside out.

Truly my *Pityophis*, in its new attire, seemed transformed in beauty, such was the contrast between the old coat and the new in the freshness of color. The white ground had a rich creamy hue, not unlike that which the ladies so admire in antique lace. There was, too, a soft warmth in the brown, the chocolate, and the chestnut. With some serpents the new skin shows a fine iridescence in the light. But this soon gives out, the old skin getting dull and lustreless, for the serpents have no power of color mimicry.

With many others I have not been able to see "the wisdom of the serpent." Still, I think we may claim for it better manners than are found among its reptilian cousins of higher rank, for in the disposition of its cast-off linen no serpent ever mistook the bread-bin for the laundry basket.

A certain eloquence has of late descanted upon "the mistakes of Moses." Might it not be pleasanter to look into the wisdom of this great leader of his race? I can only accept evolution as a method in which the Creator works His will, as when He makes one vessel to honor and another to dishonor. Appearing almost the last of the vertebrates, the serpent comes a limbless, a degraded creature. Hence this Moses struck upon a vast cosmic law which only the biology of to-day could formulate—the evolution of progression and the evolution of retrogression—that in the Creative purpose there is a differentiating backward and a differentiating forward. It surely, then, was retrospective wisdom which said of the serpent: "Doomed above every beast of the field, upon thy belly shalt thou go."

NOTE.—Up to within a few years the physiologies taught that the tadpole's tail, just before the transformation into the frog, was dropped or lost by atrophy. Even yet this idea appears in some natural histories. During the last year I read a description, by a well-

known and elegant writer, of a great number of little toads leaving the water and dropping their tails on the ground! He drew upon his imagination, not his observation. In April, 1861, I contributed to *The Rutgers College Quarterly* a paper, under the title "Crangasides: A Batrachian Biography." In that paper was shown the use of the tail as pabulum to the frog during a few days at the beginning of a critical change in life, this appendage being absorbed into the animal as condensed alimentation.

NERVES AND NERVE ACTION.

BY CARL HEITZMANN, M.D.

(Read February 3d, 1893.)

When, twenty years ago, I made the discovery that so-called protoplasm, at that time considered as the living matter, was of a highly complex structure, being traversed by a delicate reticulum, the points of intersection of which were the nucleus and the granules, my assertion met with incredulity and scorn. By and by histologists satisfied themselves that I was right. Even the French now admit the presence of such a reticulum, dubbing it "hyaloplasma." All doubts must vanish upon looking at the photomicrograph published by S. Stricker, of Vienna, in 1890, taken by means of electric light with a power of 2,500 diameters. The photograph, which I here exhibit, is that of a living, or fresh, colorless blood corpuscle of a newt, *Proteus*, from the Adelsberg grotto in Austria. The reticulum is exactly of the appearance which I described and illustrated in 1873. Since I saw the reticulum in continuous movement during the life of a protoplasmic lump, my conclusion was that the reticulum is made up of the living or contractile matter proper; whereas the meshes contained a liquid, as such destitute of properties of life, filling the meshes of the sponge-like structure, and permitting the contraction of the solid portions—*i.e.*, the living matter. The contractions consisted in a narrowing of the meshes, an increase of the size of the points of intersection, the so-called granules, and a shortening of the connecting threads. The extension, on the contrary, proved to be a widening of the meshes, a decrease in the size of the granules, and an elongation of the threads. The protoplasmic lump being ensheathed by an extremely thin layer of the same substance that builds up the reticulum and the meshes, the fluid filling the

meshes could nowhere escape from the protoplasmic lump, but was simply pressed from one portion, when contraction took place, to another portion at rest, causing the distention of the reticulum in the latter part. Should such an extremely thin, expanded flap or pseudopodium find attachment to the slide, a point of fixation is given, toward which the lump is dragged as soon as the contraction ceases and rest is established. On this principle is obtained an easy understanding of the form-changes and locomotions of the *amæba*, as well as of any other living protoplasmic lump.

The question, what living matter really is, no one can answer. Neither can we enter the discussion of the query, What causes its contraction? It is the innate property of the living matter in the lowest plant, as well as in the highly organized human form, that it contracts, thereby causing change of shape and locomotion. The second essential property is that it is able to produce its own kind by taking in food and by generation. The latter feature will not be considered in my address.

When we analyze, with high powers of the microscope, the structures termed "nervous," we come to the conviction that all these structures are made up of living matter in an extremely delicate reticular arrangement. Usually the nervous system is divided into a central portion, the brain, spinal cord, and the sympathetic ganglia; a conducting portion, the nerves proper; and a terminal portion, often consisting of knob- or bud-like formations in the peripheral organs and tissues. Undoubtedly the nervous system is continuous throughout the whole animal organism—in other words, the brain and spinal cord are continuous with all the nerves traversing the body, and these again with the terminal apparatus. Long since the nervous system had been compared with the telegraph, the central stations of which were considered to be the brain and spinal cord, whereas the wires were represented by the nerves. So close is indeed the resemblance that some physiologists have claimed that the nerve action is an electric one—an hypothesis, however, never proven.

The brain and spinal cord consist of a gray and a white substance. The white substance is composed altogether of so-called medullated nerves, and is merely a conductive apparatus. The gray substance, on the contrary, is the only central apparatus of

the nerve system. In the gray substance, again, we meet with innumerable protoplasmic bodies, the so-called "ganglion cells," or ganglionic elements, from which, as is to-day generally conceded, arise the nerves proper in the shape of so-called axis cylinders. All these bodies, therefore, are unquestionably central organs. In analyzing the ganglionic bodies we see them composed of a dense, delicate reticulum, first recognized by C. Frommann, of Jena, in 1867. Each ganglionic body sends out a thread-like prolongation, the axis cylinder, and a varying number of branching offshoots, termed, in honor of their discoverer, Dieters' offshoots. All the latter run into the gray substance at large, and only the axis-cylinder offshoot is a nerve, running from the central ganglion uninterruptedly to the periphery of the body. I exhibit such a body with a power of 500 diameters, fully sufficient to recognize the offshoot, though not the central reticulum.

Again, the gray substance is made up of a tiny reticulum of living matter, not quite as dense as that of the ganglionic elements. I was the first to discover this reticulum in perfectly fresh sections of the brain of just killed rabbits, twenty years ago; but this is an assertion of mine that has not as yet met with the confirmation of other microscopists. The reticulum is easily made visible by a stain with osmic acid, as shown here, with a power not exceeding 300 diameters. This reticulum is connected with all the Dieters' offshoots of the ganglionic elements, and again sends out axis cylinders, the same as do the ganglionic elements. This my assertion has recently found corroboration by Edinger, of Germany.

It is plain that contraction, originating in the ganglionic elements, will be conducted partly to the gray substance by the offshoots of Dieters, and partly to the periphery through the axis-cylinder offshoot, the nerve proper; for the structure of the latter is reticulated the same as is that of the ganglionic bodies and the gray substance in general.

Many facts, obtained either by experiments on animals or by observations in morbid changes of the brain, have led us to the conviction that the ganglionic elements are the seat of all our knowledge, called positive, brought into our brain from without by the organs of sense. Such a positive knowledge is, for instance, the *a*, *b*, *c* by means of which we read and write, the

1, 2, 3 by means of which we calculate and heap up dollars. Should the ganglion of *a*, in the so-called claustrum, be destroyed by a blood effusion, the capacity of pronouncing or writing an *a* is lost. Should the ganglion of number 3 be destroyed, the idea of number 3, or the capacity of writing it, will be lost. From these facts the inference can be made that the ganglionic bodies are central organs for concrete or positive facts; whereas the gray substance is central for diffuse nerve action, such as fancy, religion, dreaming, fears, hopes, etc. The gray matter of the frontal lobe is the seat of intelligence, as first maintained by Th. Meynert, the regulation of our acts by judgment and adaptation. Hence all mental diseases—disturbances of the intellect—are located in the frontal portion of the brain.

In all nerves running from the central organs to the periphery of the body the most essential and only conducting thread is the central axis cylinder, which is either bare, such as in non-medullated nerves, or supplied with a sheath of nerve fat, or myelin—an insulating substance seen in the medullated nerves, furnishing them with a whitish tint, due to the opacity of the myelin in surface illumination. The axis cylinders, I said, have a delicate reticular structure. Any nerve, though originally medullated, will, upon approaching the surface, lose its myelin coat and split up into a number of extremely delicate so-called axis fibrillæ, best rendered conspicuous by a stain of chloride of gold, introduced into histological technique by the late Jul. Cohnheim, of Germany. All we can recognize on such axis fibrillæ, with the highest powers of the microscope, is a beaded or rosary-like appearance, a series of minute dots, interconnected by the most delicate threads. Evidently this feature is a reticulum transformed into a linear projection of threads and granules, eminently fit for contraction. I exhibit here the cornea of a cat, stained with chloride of gold, showing the axis fibrillæ as they inosculate with the protoplasmic formations, termed cornea corpuscles.

With these facts at hand we may reasonably assert that what we call nerve is a complex reticulum of living matter, either arranged diffusely, as in the gray substance; or condensed into a bulky formation, termed ganglionic element; or arranged in rows, as in the axis cylinders; or in a linear projection, as the axis

fibrillæ. Since contractility is one of the main properties of the living matter, we again must come to the conclusion that the nerve action is altogether due to contraction of living matter. Should the contraction start in the periphery, as, for instance, by a prick with the needle, or a burning match, the contraction is carried centrifugally and results in the sensation of pain. By complex systems of association through the gray substance, the motor centres, which are the largest ganglionic formations, are brought to contraction, which they convey toward the periphery, especially to the muscles, and the result of this centrifugal contraction is motion, either involuntary or reflex motion, or a motion controlled by the gray matter of the brain, mainly its frontal lobes.

While I was publishing my works on protoplasm in 1873 in the Vienna Academy of Sciences, where these views were laid down for the first time, Prof. Th. Eimer, in Germany, published his researches on jelly-fish of the Mediterranean Sea. He succeeded in fixing the minute tissue relations by means of osmic acid. As you see in his illustrations, he claims that in these animals nerves and muscles are continuous formations to such an extent that the beaded axis fibrilla directly changes into striped muscle. This goes far to prove the correctness of my own view. Both nerve and muscle work upon one and the same principle of contraction of the living matter. I have demonstrated the continuity of motor nerves with the sarcous elements of the striped muscle fibres; but the majority of histologists do not as yet admit such a continuity.

In a previous meeting Mr. Hyatt claimed that plants exhibit a certain amount of intelligence and voluntary movement, though they lack both nerve and muscle. My views will easily explain the phenomena. The protoplasm of the plant has a reticular structure exactly the same as that of animals. The reticulum is the living or contractile matter in plants as well as in animals. A contraction, being induced at some peripheral point of the plant, is conducted by the threads of living matter, piercing all cement substances throughout the whole organism, and the motion, so striking in some plants, will result. No intelligence and no voluntary action are needed to perform what the plants do. What we call voluntary action in animals, especially also in

men, is to a great extent only automatic or reflex action. What we do we must do, owing to the contraction of our brain, and so-called will plays a trifling part in controlling our actions, mainly under the guidance of the frontal lobes of the brain.

THE OCCURRENCE OF MARINE DIATOMS IN FRESH WATER.

BY ARTHUR M. EDWARDS, M.D.

(*Read February 17th, 1893.*)

Even the amœba, that formless mass of jelly, begins somewhere and somehow. The diatomaceæ have a beginning, but what that beginning is, and when, and how, is uncertain. But when they began, was it as inhabitants of fresh water, in ponds and rivers, or of salt water, in the ocean? This can be determined with a certain degree of assurance by examining the strata where their silicious loriceæ are preserved.

Since I began studying the diatomaceæ, now some forty years ago, their beginning was a subject of constant inquiry, and I think I can now determine with positive certainty that their origin was in fresh-water strata.

The sea, that formed from the falling rain, was fresh, of course, and became salt by the solution of hydrochloric acid and sulphurous acid, and then, further, by the solution of certain salts from the earth. After a time the rain which collected fell as fresh water on the earth and formed ponds, lakes, and rivers. But whether they or the salt sea were formed first is undecided. Fresh-water diatomaceæ formed in some places first, and were carried downward and became brackish and at last salt, as can be proved by examining the strata, as I shall show. At least, such is the inference.

The gathering of which I speak now is from Hatfield Swamp, on the Passaic River, New Jersey. It is about thirty miles above Newark, following the tortuous course of the stream, but only nine miles distant across the country, the Hatchung Mountains, in two ranges, intervening. At Paterson are situated the Passaic Falls, seventy feet in height, and at Little Falls, four and one-half

miles up the stream, an additional fall of fifty feet occurs. Hatfield Swamp is about three and one-half miles long by one and one-half miles broad, and the deposit is clay, about three feet and eight inches deep, where I took the specimens. At Columbia Bridge, four miles further, is a small patch of similar clay, perhaps one hundred feet broad.

Besides the ordinary fresh-water forms, *Navicula* (*Pinnularia*) *viridis* and similar species, there are found two salt-water forms of *Actinocyclus Ralfsii* and *Campylodiscus echeensis*. These are both common in the Hatfield Swamp clay, the *Actinocyclus* as brilliantly colored discs, and the *Campylodiscus* as large, white, saddle-shaped forms. These are also both common on the coast in salt water. And the first is further well known in the guano at Ichaboe, at the Cape of Good Hope. These diatoms cannot be carried up the stream by the tide, as that does not reach higher than ten miles above Newark, some distance below Paterson, and there intervene between the tide and the swamp more than one hundred feet of falls, seventy feet of which are perpendicular at Paterson.

I present some of the clay, and a slide mounted to show the mixture of fresh-water and salt-water forms. Diatoms having originated in fresh water, they may present the same characteristics when transferred to salt water, or they may change totally. How this change goes on has not been determined, but the Hatfield Swamp clay shows that recognized marine forms may live in fresh water, and fresh-water forms have been seen living in the ocean.

PROCEEDINGS.

MEETING OF FEBRUARY 3D, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Forty four persons present.

The Corresponding Secretary presented a donation of diatomaceous material from Mr. K. M. Cunningham, of Mobile, Alabama, with an explanatory communication, dated January 30th, 1893, as follows :

"I forward specimens of a new fossil marine diatomaceous deposit, with the object of putting the find upon record, and of

providing such members as are interested in diatomology with the means of verifying my own study of the same.

“As far back as the year 1878 my attention had been called to the statement made by Prof. J. W. Bailey, in his microscopical observations made in the year 1852, and recorded in the Smithsonian ‘Contributions to Knowledge,’ that he had detected evidence of marine diatoms in an indurated clay found by him on the shores of Hillsborough Bay, in the vicinity of Tampa, Florida, but from which he had been unable to isolate the diatoms on account of the stony character of the material. Through the intervening years I, from time to time, tried to secure specimens of the material as noted by him, but such specimens as I secured failed to corroborate the fact of diatom contents.

“As a consequence, however, of faith in his statement, I persisted in the hope, and my hopes were realized very recently, as the casual outcome of finding a schooner discharging here a cargo of Florida River pebble phosphates. Examining the composition of the pebble aggregations, I noted the recurrence of flattened, water-worn, and rounded nodules of a clay-like substance, which I found could be easily split into thin layers indefinitely. Applying a hand lens, the clay yielded its secret, as each fractured surface showed innumerable diatomaceous bodies, indicating its marine origin as well as fossil nature.

“The interest in this find is emphasized, as it possibly throws new light on a geological question—*i.e.*, as to whether fossil marine, diatomaceous strata of miocene age could be found on the United States Gulf coast of the same character as those on the Atlantic coast. While the generic assemblage of species does not agree with the Maryland and Virginia miocene diatomaceous clays, the geological horizon may be the same, as the phosphate deposits of the Florida peninsula were laid down upon eocene limestone strata. It is known that the valuable phosphate rock nodules and organic vertebrate remains are embedded in a clay that must be removed by washing, and the presumption is that the clay, whenever this is the case, is of the infusorial or diatomaceous kind.

“The clay material, as sent to the Society, may be conveniently studied in various ways. Split into thin layers and examined by condensed light, analogy will suggest a resemblance to the dia-

tomaceous clays of Richmond, Virginia, in the profusion of discoidal forms covering the surface. These forms, however, are but spectral, as they vanish on wetting. The nodule, rubbed down in water with a brush, will leave a sandy sediment containing sponge spicules, polished sand grains, ovoid amber-like grains, and species of disc forms of the following genera : *Coscinodiscus*, *Actinophtychus*, *Actinocyclus*, *Triceratium*, and minute plates showing a plexus of *Melosira* and *Raphoneis*, the diatoms having been metamorphosed in such manner as to be soluble in nitric or other acids, the same as the organic phosphatized remains of the vertebrates associated with the clay. Finally, the clay may be thoroughly disintegrated by boiling in strong soap solution, and after standing for ten hours it will be reduced to a homogeneous sediment, readily washed and cleaned for examination.

“Concentration of the diatoms from the sand is very difficult, on account of the similarity of the specific gravity of the diatoms and of the sand and other grains associated therewith. Acid treatment, being in this case impracticable, must be avoided. The material is adapted for selected or for strewn mounts. In the latter method a few of the prevailing species may be studied with interest and satisfaction, thereby affording something novel in the marine fossil diatomaceous line of research apparently not heretofore recorded.”

Dr. Carl Heitzmann addressed the Society on “Nerves and Nerve Action.” This address was illustrated by exhibits, as noted below, and an abstract of the address is published in this number of the JOURNAL, page 66.

OBJECTS EXHIBITED.

1. Diatomacien genus-platte. *Triceratium trinacria*, 280 forms, prepared by E. Thum, Germany : by HENRY C. BENNETT.
2. Mouth-parts of Tapeworm : by L. SCHÖNEY.
3. Photomicrograph of *Navicula crassinervis* (Spencer $\frac{1}{6}$) : by H. G. PIFFARD.
4. Motor ganglion of spinal cord of child.
5. Transverse section of gray substance of spinal cord of rabbit.

6. Transverse section of white substance of spinal cord of bear.

7. Cornea of cat, stained with chloride of gold.

Exhibits Nos. 4-7 all by CARL HEITZMANN.

MEETING OF FEBRUARY 17TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Nineteen persons present.

Mr. George H. Blake was elected a resident member of the Society.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, of Mobile, Alabama, dated February 8th, 1893, and accompanying the donation of a slide of selected diatoms from the Florida diatomaceous clay, as follows :

“With the view of placing upon record in a more definite manner the recent find of a fossil marine diatomaceous deposit derived from the phosphate area in the vicinity of Tampa, Florida, and of which I duly forwarded specimens to your Society, I have made a further study of the same by microscopical preparations, one of which is sent you herewith, and I would offer as a result of that study the following observations as illustrative of the character of the deposit.

“From a portion of the cleaned material I selected free-hand about seventy perfect and fractional discs, and, upon studying the same in detail with a $\frac{1}{6}$ Zeiss objective, I can state that the surface ornamentation on the various species of *Coscinodiscus* found in the deposit prove to be hexagonal scales, which may be partially or wholly detached from their discoidal bodies, thus leaving smooth surfaces, with or without traces of the striate-punctate places of union of the scales with the frustules. In many cases where the reticulated ornamentation is wanting and the surface of the disc is left smooth, innumerable minute diatoms of various species may be seen, overlying the surface, or possibly forming a part of the internal or histological structure of the shell, during the secretion or growth of the silicious layers of the frustule during its living state. Were this view to be entertained, it would introduce an element of doubt in the present view

of the diatom being a plant instead of belonging to the infusorial group, as Ehrenberg had at first placed it.

"As tending to prove that the minute diatoms, visible through, or upon, or in the body of the disc, are not casual surface débris of the deposit in which the discs grew, I would mention the following as a very delicate test. In one of the discs on the slide there is a minute *Dictyocha* partly overlapped by a minute diatom of the *Navicula didyma* shape. To view either of these small diatoms distinctly, a material movement of the fine adjustment must be made; for while one is in focus the other is out of focus, thus showing that they are not on the same superficial plane. Again, many of the minute diatoms offer a strong contrast with the transparent disc, as would be the case where diatoms are seen in such a refractive medium as liquid sulphur, in which the diatoms look black by contrast with the enclosing medium; or where mediums are compounded with phosphorus, giving the highest refractive value. If a lens of high power, say a $\frac{1}{1\frac{1}{2}}$ or a $\frac{1}{1\frac{1}{5}}$, is used, these minute diatoms will prove of greater interest than the larger discs with which they are associated. My experience with the new diatom material has given me an entirely novel field of interest and study, which is within the reach of all whose forte is to unravel new truths and evolve new lines of thought in relation to the histology of the diatom.

"In having placed this new source of diatoms on record with the New-York Microscopical Society, we have types of diatomaceous deposits from the three principal geological eras of the tertiary period: the eocene, by the diatoms from St. Stephens, Alabama (tripoli); the miocene, from the Florida phosphate clay; and the pliocene, from the clays encountered at a depth of seven hundred feet in the Mobile artesian wells; not to mention the recent, or living, species surviving through these long periods of sedimentary deposition. In summing up the result of a limited amount of study of this miocene fossil diatomaceous clay, I find the following genera represented: *Craspedodiscus*, *Coscinodiscus*, *Actinopticus*, *Triceratium*, *Biddulphia*, *Melosira*, *Navicula*, *Raphoneis*, *Pleurosigma*, *Synedra*, etc."

Dr. Arthur Mead Edwards, of Newark, New Jersey, being introduced by the President, addressed the Society on "The Occurrence of Marine Diatoms in Fresh Water." This address

was illustrated by preparations exhibited, as noted below, and is published in this number of the JOURNAL, page 71.

Dr. Edwards also donated to the Cabinet of the Society a packet of the clay of Hatfield Swamp and a prepared slide of diatoms from the same. Dr. Edwards further gave an account of his experience with the use of Gum Thus, from *Pinus tæda* L., as a mounting medium in place of Canada balsam.

On motion the thanks of the Society were tendered Dr. Edwards.

OBJECTS EXHIBITED.

1. Seven slides, containing 1,021 diatoms, prepared by E. Thum, of Germany : by HENRY C. BENNETT.

2. Möller's Probe Platte, 80 diatoms, arranged in lines with names photographed beneath : by CHARLES S. SHULTZ.

3. Diatoms from California : by FRANK D. SKEEL.

4. *Bacillaria paradoxa*, living in aquarium since October, 1892 : by STEPHEN HELM.

5. Fossil diatoms from Manatee River, Florida, prepared by K. M. Cunningham : by J. L. ZABRISKIE.

6. Diatoms from Hatfield Swamp, N. J.

7. " " Nutley, N. J.

8. " " South Plainfield, N. J.

9. " " "Kettle Hole," near Plainfield, N. J.

10. " " Columbia Bridge, N. J.

Exhibits Nos. 6-11, all mounted in Gum Thus, prepared and exhibited by DR. ARTHUR MEAD EDWARDS.

MEETING OF MARCH 3D, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-eight persons present.

The Corresponding Secretary read a communication from Mr. Charles S. Fellows, of Minneapolis, Minnesota, accompanying the donation of a slide of *Terpsinoe musica* to the Cabinet of the Society, and dated February 19th, 1893, as follows :

"I noticed in the JOURNAL a letter, read October 21st, 1892, from Mr. Cunningham, regarding *Terpsinoe musica* Ehr.

"In 1883 I found this form in Florida. A spring took its rise

in a limestone ledge, and on the edge of the crevice, where the water ran through, I scraped off the dark slime and examined it when I arrived home.

"In looking over my slides I found one put up by J. D. Möller, marked '*Terpsinoe musica* Ehr. A. dulce, Porto Rico,' showing that at that date it was known as a fresh-water diatom.

"I find only one slide in my collection, a very poor one, put up by me in 1883, which I forward with this. Your members can compare it with the Cunningham mount. I would like to know if it differs from his."

The Corresponding Secretary also read a communication from Mr. K. M. Cunningham, dated Mobile, Alabama, February 24th, 1893, as follows:

"The information in your favor of the 20th instant suggests, the propriety of my stating upon what ground I reported the diatomaceous clay of miocene age.

"In effect, possibly eight years ago, and also at a later period, Mr. Lewis Woolman, of Overbrook, Pa., member of the Philadelphia Academy of Sciences, opened a correspondence with me to secure my assistance in collecting material to aid his geological inquiries. He intimated that he had a theory which he desired to verify—namely, that the great diatomaceous stratum of 300 feet, more or less, in thickness, studied by him as underlying New Jersey, Maryland, and Virginia, would possibly be found existing on the Gulf coast—and that he had special reasons for holding this theory. After several years nothing confirmed his hopes until I communicated to your Society and to him the occurrence of the polycystinous, diatom, and foraminiferal clay stratum at St. Stephens, Alabama. This fact renewed his hopes, and, while the clay was associated with undoubted eocene strata, it was not what he desired to corroborate his hypothesis. He wanted a clay of miocene age, which the former was not.

"Next I followed the subject through the boring of several artesian wells at Mobile, and sent him the micro-fossil organic evidence of the strata encountered at 700 feet—the foraminifera, and a special minute bivalve whose specific name is still in controversy—indicating that the pyritized marine diatoms found in the clay were of pliocene age. So to this point we had not reached a miocene clay.

“But when I made my last find of Tampa fossil diatomaceous clay, I communicated with Mr. Woolman, and told him that an illustrated article in the *Engineering Magazine* noted that geologists had stated that the productive phosphate area had been ‘laid down upon eocene limestone strata, which had not been submerged after the upheaval.’ I do not know what construction Mr. Woolman put upon this, but he replied that, if the pebble phosphate was dredged from the Manatee River, Dr. Dall had found distinct miocene fossil shells at Manatee. After he had an actual inspection of the clay, he replied that it struck him as equivalent in age to the Virginia outcrop of miocene clay strata, the same as that which he had studied at Atlantic City and elsewhere, and that he had also consulted Dr. W. H. Dall’s latest map of the geology of the Florida peninsula, in which the Fernandina and St. Augustine coast was designated as ‘newer miocene,’ and the Tampa coast as ‘older miocene,’ and he proposed making a communication touching the new clay, based on these recently collected data, to the Philadelphia Academy of Sciences as promptly as possible.

“Mr. Woolman had in preparation a paper on a diatom deposit encountered at depths between 90 and 150 feet, in artesian borings at Ponce de Leon Hotel, St. Augustine, Florida, but said that he had not fully settled upon the age of the foraminiferal forms found in his boring samples, and this is why his work has not been put upon record.

“Mr. Woolman was highly gratified at my discovery, as he said that geologists, for two years past, had tried to trace the diatomaceous clay or rock near Tampa on Hillsboro Bay, mentioned by Prof. J. W. Bailey in his microscopical researches about 1852, but without success. He said that he would defer to me, and if I would inform him when my find was put upon record with the New-York Microscopical Society, he would then make his communication to the Philadelphia Academy, giving me full credit for the discovery. So far as he could ascertain, this fossil marine deposit had not been announced by any one previous to myself, although he had been studying diatomaceous and foraminiferal forms from St. Augustine, secured more than a year ago.

“Dr. Edwards wrote me that he thought the clay of eocene tertiary age, and I wrote in reply the material points contained

herein in reference to its being of miocene age. However, if the clay is not of miocene age, it can be so put provisionally until other proof is adduced to the contrary."

OBJECTS EXHIBITED.

1. A substitute for the camera lucida: by H. G. PIFFARD.
2. A microscopical electric illuminator: by H. G. PIFFARD.
3. Arranged spines of *Echinus*: by H. G. PIFFARD.
4. A Zentmayer portable microscope: by WALTER H. MEAD.
5. A simple form of compressor: by WALTER H. MEAD.
6. A Tolles micrometer ruling: by GEORGE S. WOOLMAN.
7. A Rogers micrometer ruling; by GEORGE S. WOOLMAN.
8. A home-made dissecting microscope: by F. W. LEGGETT.
9. A Beck microscope lamp: by CHARLES S. SHULTZ.
10. An enlarged model of Smith's vertical illuminator: by CHARLES S. SHULTZ.
11. A metric scale, ruled by Prof. W. A. Rogers on speculum metal, shown by means of the Beck lamp and the vertical illuminator: by CHARLES S. SHULTZ.
12. *Asellus aquaticus*, living: by HENRY C. BENNETT.
13. Sections of spines of *Echinus*: by JAMES WALKER.
14. Automatic revolving stage: by JAMES WALKER.
15. Automatic revolving polariscope: by JAMES WALKER.

Dr. Piffard explained his substitute for the camera lucida—a right-angled prism fitted in place of the eyepiece of the microscope, through which the image is projected downward perpendicularly upon the drawing paper lying upon the table; also his electric illuminator—a cylindrical glass bulb, three inches in length by one inch in diameter, the illuminating filament, of the ordinary horseshoe form, being composed of copper wire, with the exception of three-quarters of an inch in length of the middle portion of one limb of the horseshoe, which portion consists of carbon. This carbon, when incandescent, gives a streak of light of intense brilliance about three-quarters of an inch long and apparently about one-eighth of an inch wide. The magnified image of this, focussed upon the object, gives "critical" illumination. Diffuse illumination is obtained by racking the condenser a little out of focus.

Mr. Mead described his exhibits—a Zentmayer portable micro-

scope, made twenty years ago, of exquisite workmanship, having no fine adjustment, but an excellent coarse adjustment ; also a stage compressor of unusually easy operation.

Mr. Leggett described his home-made dissecting microscope, comprising adjustment for the lens, swinging mirror, and firm, ample stage.

President Shultz explained his greatly enlarged model of Smith's vertical illuminator, which he had constructed for the occasion, exhibiting plainly, at one view, to the entire audience the operation of the apparatus.

Mr. William Wales said that, in conjunction with Prof. Hamilton L. Smith and Mr. George Wale, he was engaged during two years in carrying out Prof. Smith's ideas of the vertical illuminator. They made both forms—glass and metal reflectors. The apparatus was patented by Prof. Smith and the patent was assigned to Mr. Wales.

Mr. George S. Woolman corroborated the statement of Mr. Wales, and said the credit of the invention was due our country.

Mr. Shultz stated concerning his exhibited metric scale that Prof. Rogers worked for a year over this admirable scale. It was soon found that speculum metal afforded the best lines, and the most uniform power for actuating the ruling machine was obtained from a weight elevated high in the building containing the machine.

Mr. Walker explained the method of cutting his sections of spines of *Echinus*—the spines were thrust firmly into the holes of ordinary pearl buttons, cemented in place with balsam, cut off close to the buttons with a saw, and then spines and buttons together were ground down to proper thinness on successive stones. Mr. Walker also described his automatic revolving stage and polarizer, actuated by clockwork.

Dr. F. D. Skeel explained with blackboard drawings his improved attachment for moving the fine adjustment of the microscope in photography ; the main point of which improvement consisted in carrying the long, endless cord, at the side of the camera, to a grooved pulley on the stand below the fine adjustment, and then coupling this pulley with the grooved milled head of the fine adjustment by means of an additional short, endless

cord. This arrangement gives very easy, uniform motion, and avoids all unequal strain upon the fine adjustment.

MEETING OF MARCH 17TH, 1893.

The Vice-President, Dr. Edw. G. Love, in the chair.

Twenty-six persons present.

Mr. Frederick Kato was elected a resident member of the Society.

Dr. Arthur Mead Edwards read a paper entitled "On Mounting Objects in Substances of High Refractive Index." Dr. Edwards also donated specimens of Gum Thus to the Cabinet and for distribution.

OBJECTS EXHIBITED.

1. Brass slips for diffusing heat in mounting : by ARTHUR MEAD EDWARDS.

2. A super-stage for elevating the object above the stage of the microscope, allowing very oblique light from beneath : by ARTHUR MEAD EDWARDS.

3. Inexpensive slides of diatoms, prepared by P. Klavsen : by ARTHUR MEAD EDWARDS.

4. Samples of purified Gum Thus, *Styrax* extracted by xylol, and of Iodide of Methyl : by H. G. PIFFARD.

5. Diatoms mounted in *Styrax* : by H. G. PIFFARD.

6. Human skin undergoing calcification : by H. G. PIFFARD.

7. *Pleurosigma* Genus Platte, 70 forms, mounted in monobromide of naphthalin : by HENRY C. BENNETT.

In reply to the question by Dr. F. D. Skeel, "Can diatoms be stained?" Dr. H. G. Piffard replied in the affirmative, referring to the accounts by M. Tempère, of Paris. Dr. Skeel stated that agate can be stained by successive immersions in honey and sulphuric acid, and that many carnelians and agates are thus stained.

Rev. J. L. Zabriskie gave some points of his experience on the ease and rapidity of mounting in glycerin. In case of objects 0.001 of an inch or less in thickness, permanent glycerin

mounts can be made without the employment of any cell. Spin with the turn-table a guide ring of India ink, about one-sixteenth of an inch larger in diameter than the intended cover, upon either the upper or lower surface of the glass slip; place a minute portion of the glycerin—the proper quantity for different sized covers being soon found under a little practice—in the centre of this ring with a rubber bulb “dropper” to avoid bubbles; insert the object in this glycerin by means of needles; lower the cover glass upon the object very slowly; avoid squeezing out the glycerin beyond the cover, using only delicate pressure with the needles, sufficient to cause the fluid to spread to the entire periphery of the cover; seal the mount at once with a solution of brown shellac in alcohol, used as thick as will flow easily, which shellac will form a jelly by union with the glycerin at the edge of the cover, thus preventing the running in of cement subsequently applied; set the mount aside for twelve or twenty-four hours; and then finish with a cement consisting of equal parts of Japan gold size and ordinary asphalt varnish. One coat of this cement will hold for a long time, but it is better to use successive coats, laid on at intervals of twelve or twenty-four hours, until a smooth, bevelled ring covers the edge of the mount.

In the use of a cell of any considerable depth, where it is not so easy to avoid excess of glycerin, after the cover is gently pressed down, apply a spring clip of very moderate force, only sufficient to maintain its own position when the slide is handled; wash away the excess of glycerin by holding the mount slightly inclined under a gentle stream of water, about the diameter of a lead pencil; avoid drawing out the glycerin by attempting to wipe the cover or its joints, but blow away the adhering water with smart puffs of breath; place the mount on the turn-table, with the spring clip still in its position, and seal at once with the shellac solution, and after twelve or twenty-four hours cement with the black mixture as before.

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NOTES ON SOME RESEARCHES AMONG THE
DIATOMACEÆ.

BY K. M. CUNNINGHAM.

(Read November 17th, 1893.)

By a peculiar trend of events my attention had recently been called to the question of the plant or animal nature of the diatoms. This question had hitherto been of little interest to me, very nearly all of my interest having been directed merely to an accumulation of specimens of fossil or recent deposits and the study of their distribution. But certain favorable opportunities have enabled me recently to devote some attention to the study of living diatoms. With this object in view I have prepared, and, after due study of the same, I send herewith the series of slides illustrating this paper as a donation to the Society.

It may be of historic interest to recall the fact that in the "Smithsonian Contributions to Knowledge" there is a publication, bearing the date of 1850, and entitled "Microscopical Observations made by J. W. Bailey, of West Point, N. Y., during a tour through the States of South Carolina, Georgia, and Florida," in which work were listed and tabulated all infusorial and other microscopic forms of life encountered in his travels through the said territory, including the diatoms and the desmids, with figures of the new species found by himself. Since the year 1878,

when I became aware of the existence of the publication, its subject has lain as a dream in my mind. Years after, when I had become quite familiar with the diatoms of both the South and the North, I recalled that in his tabulation from all sources he had listed about ninety-four species, including both marine and fresh-water, and never exceeding more than twenty-five species from a given locality. It has also been a matter of curious interest to me as to the methods of preparation for study in vogue in or about 1850. In the present day, as proved by my slides, I have been able to get eighty species in a single mount from Mobile Bay marine muds, and nearly seventy-five species from the brackish material from the shore of Mobile Bay—the same material as apparently examined by him from Mobile Bay. In alluding to this, I do so with full respect for the eminence of the most prominent investigator, in his day, of the diatoms of North America, and not with any desire to detract from the honor of his laborious researches; but the thought calls up the question as to whether the methods of to-day are in advance of those of nearly a half-century ago. In the preparation of this paper I could not well omit the name of Prof. J. W. Bailey, as its interest turns largely upon a diatom described and figured by himself from material derived from Mobile Bay, and shown in the plates to his work referred to above; and likewise shown in Wolle's "*Diatomaceæ of North America.*"

The opening during the present summer of a resort on Mobile Bay, known locally as Monroe Park, by the Electric Railway Company, enabled me to visit a strip of the shore of Mobile Bay a few miles south of the city. While there, and looking around for something of interest microscopically, I came upon a stratum of lignite exposed on the beach at low tide. I repeated my visits to this place to study it geologically. With a desire to trace its extension, I made short excursions somewhat further down the shore line from the Park, especially on occasions when the tide was out in the evening. In this area the bay bottom was covered, so far as the surface was free from the tide, with a species of a moss-like water plant, which condition induced me to test whether this moss-like growth would prove a source of diatoms. I therefore gathered a portion of a plant, and by pressure forced the fluid to fall on a spectacle glass used for such tests in the

field. On drying the glass I examined it, and was rewarded by finding an abundance of diatoms, including a species which I had nearly despaired of ever finding or seeing. This proved to be Bailey's *Amphiprora ornata*, as figured in his "Microscopical Observations, etc., in 1850." During all the previous years of my diatom researches I had desired to find *Amphiprora* of any kind whatever, but apparently in vain. Having my "treasure trove," I secured one full plant with its complement of mud, and it is from this, and a second supply of the clean plants, that I have prepared the series of six slides typical of the original material that Bailey must certainly have examined, as he referred to material often gathered from bogs or on shores where the diatom ooze abounded.

On the very same evening that I secured this moist water plant I spent some hours in its examination, applying myself more particularly to the character of the motion of the living diatoms. It took me but a moment to find on the slide specimens of living *Amphiprora* and *Navicula*. Confining my attention closely to the appearance and structure of *Amphiprora ornata*, I was enabled to observe that, if a bacterium drifted toward it and made contact, it would be held as a prisoner in the full power of the protoplasm covering the diatom externally. As is well known through mounted specimens, as well as figures, *Amphiprora* has delicate, hyaline, and rather broad alate lateral processes. Bacteria and rotifers, once in contact with the peripheral edges of the alæ of the *Amphiprora*, are kept in a constant state of alternate or reciprocal motion from either diametrical extremity. That is to say, the bacterium or other organism is rapidly transported from the middle constriction to one or other of the extremities of the diatom, all the way, or part of the way, in an alternating manner; when it may, after an interval of detention, be rejected by what appears to be a voluntary impulse of the *Amphiprora* itself. Having seen this phenomenon, I at once became aware of its importance in any discussion involving the plant or animal nature of the diatom, and more particularly as all my previous acquaintance with the Diatomaceæ had permitted me to remain content with the generally accepted opinion that the diatom was "a lowly unicellular plant."

This accidental discovery of the motility of the protoplasmic covering of the *Amphiprora* induced me to see what was already of record in relation to the cause of the directive motion of many genera of the Diatomaceæ, but more particularly the Naviculæ. I forthwith consulted all the available references to the life history of the Diatomaceæ within reach. Neither the "Encyclopædia Britannica," latest (ninth) edition, "The Columbian Cyclopædia" (1892), "Micrographic Dictionary" (1856), "Carpenter on the Microscope" (1856), Rev. Francis Wolle's "Diatomaceæ of North America" (1890), "Generalities, on the Diatomaceæ," of Count Abbé Francesco Castracane (1884), nor the address of ex-President Charles F. Cox before this Society, entitled "What is a Diatom?" and published in full in the JOURNAL (January, 1892), contained the slightest reference to, or a suggestion of the phenomena partially described in the preceding introduction, but most or all of the authorities confined their notice to the distinct and evident motion of translation of the diatom frustule in a simple direct or retrograde motion. The mystery of its motion was left involved in hypotheses, and no satisfactory solution was offered by the various observers. That any diatom had a dual or a subsidiary motion was everywhere regarded in the negative or not entertained at all. The *Amphiprora*, which clearly exhibits this dual power, is not mentioned at all. The fact that *Amphiprora* has some of the attributes of protozoan life, rather than that of plant life, had been hitherto overlooked, or at least seems to not have been specifically alluded to, especially as appears in Wolle's "Diatomaceæ of North America," which presumably should give the highest reach of experimental research obtaining on this subject to the year 1890. In the opinions submitted therein the cause of the motion of diatoms remains a mere hypothesis requiring elucidation. And no authors so far have touched upon the subject of the dual or compound motion exhibited by *Amphiprora ornata* or any other species of *Amphiprora*.

After my initial experience related above, I made a second visit to the bay shore, and carried along a collecting bottle, into which, from a new supply of the peculiar moss-like water plant, I expressed as much fluid from it as I deemed necessary, and at night proceeded to study it *de novo*. By the most delicate manipulation known to me I freed the material from sand, and by repeated

washings in water and by a special form of concentration I secured a dip to examine on an uncovered slide. For a period of three hours I watched the various living and moving diatoms, noticing closely every condition presented by such as appeared, but seeking especially to keep in the field an *Amphiprora ornata*, which is one of the smallest of its genus, but sufficiently large to study clearly. The same phenomena were presented as in the first experiment, but with this variation: after observing a bacterium that had touched the edge of the ala on the left side, it was oscillated a few times alternately, and was then transferred along the edge of the ala to the constriction, and then continuously across the broad central portion of the frustule to the ala on the right side, always along the periphery, and on to the opposite extremity of the diatom, where it disappeared. Immediately after this a good-sized, motionless rotifer drifted into contact with the left ala and was rapidly rotated along the edge of the ala on the left side, and was then carried to the middle constriction, where it was retained some time, when it was rejected by the diatom. While the rotifer was being manipulated on the left side a bacterium was performing its oscillations on the right periphery, and what appeared to be a cluster of bacteria were held prisoners above and around the middle portion near the constriction of the alæ.

Another feature of interest attaching to the motion of *Amphiprora* is that in the event of its being capsized by striking some obstacle in its path of motion, if thrown on its narrowest edge—front view—it at once struggles to regain the position, which displays its side view, and then its motion continues direct and rapid. This action intimates an intelligence akin almost to that of a beetle on its back exerting itself to regain its natural position on its feet.

While shifting the field in order to observe some other indications of the life motions, I observed a simple, small *Navicula* having in contact at one of its sublanceolate ends a *Nitzschia closterium*—closely agreeing with Wolle's figure. The *Navicula* seemed to be rapidly driving the *Nitzschia*, in the manner that a violin bow is rapidly drawn by rising and falling strokes, or in a see-sawing motion, while the *Navicula* was quiescent. This produced the illusion of the source of motion being situated at the prow or apex of the *Navicula*. But a moment later the illusion

was explained by seeing another *Nitzschia closterium*, having attached to its exoplasmic layer foreign particles that were being rapidly transported around its entire periphery, from the right side around to the left, sometimes direct, sometimes alternating. At another time I saw a small rotifer held a prisoner by a small *Navicula*. At times the rotifer moved away a space equal to its diameter, but was drawn back each time into a fresh contact with the edge of the diatom, as if by some invisible force. While still in contact with the *Navicula*, it drifted or was drawn between the *Navicula* and an *Amphiprora* into a sort of cul-de-sac. I saw also that under this mysterious force it vibrated rapidly between the two diatoms—the rotifer, being inert, had not an independent power of motion to release itself from its captors. In the drop of water on the slide there were numerous and very active small *Naviculæ*, whose motions presented nothing of special interest, except possibly that they often came in contact with larger *Naviculae* and passed by in contact with the protoplasmic sheath of the larger diatoms, and soon parted company with them, as their motion was swifter and not retarded by the sliding contact. This will suffice to record such observations as were derived from a painstaking study of material taken from the shore of Mobile Bay and examined within an interval of six hours.

Desiring to gather additional data bearing upon the behavior of the living diatom under the lens, I had, about a week previously, secured some fresh-water diatoms directly from a natural spring at the village of Whistler, Ala., five miles north of Mobile. On a visit to the same locality in March last I casually found a beautiful, clear spring flowing from a grassy, sloping hillside into a barrel sunk flush with the grassy surface of the adjacent ground. Selecting a small sample of the algæ through which the spring flowed away, I expressed the fluid therefrom on a spectacle glass, and examined it with a pocket lens. I was surprised to find the glass surface covered with a pure gathering of *Navicula viridis*, all united in fours, or what I would call “tetradelphias.” I then collected in a bottle a portion of the material and took it to Mobile for examination as to the number and association of species. But too much extraneous matter prevented a suitable slide from being prepared, and the beautiful phenomenon of the spectacle glass could not be repeated. On a recent

visit to the same spring, in the early part of September, I took with me a one-ounce bottle with parallel sides and semi-cylindrical ends, which form was useful in the subsequent observations. Having in mind the subject of the motility of the brackish-water diatoms of Mobile Bay, I desired to pursue the subject further with a distinctly fresh-water variety of diatoms. The material expressed from the algæ of this spring I studied for five consecutive days.

On the evening of the day that I secured the Whistler material I prepared a portion for examination, by repeated washings, settling, and changes of water, and then placed a drop on a slide, when I found an abundance of living *Navicula viridis*—single large individuals, and shorter ones grouped in fours and adherent to each other. The first fact verified was that during the interval between March and September the diatoms were still largely represented by the fourfold combination seen on my first visit to the spring in March.

The following is a résumé of what I observed during a close study of the living material. On the first night of my study I sought to detect, if possible, the presence of the protoplasmic mantle or sheath as demonstrated and observed by Cornelius Onderdonk, and recounted by him in *The Microscope* (1890). Having the living diatoms at hand, I made a concentration and removed as much water as possible in order not to weaken the dye. I also had convenient a bottle of aniline violet ink to use in the attempt to differentiate the protoplasmic mantle as indicated by Onderdonk. On adding a few drops of the aniline dye to the living frustules, I quickly placed a drop of the diatoms on the slide and covered the same with a three-quarter inch cover glass. My surprise was great when I observed that the diatoms had been instantly killed by the liquid. All that portion of the field not occupied by the diatoms or débris gave no color indication. After a fruitless search for any indication of an evident protoplasmic layer, I came to the conclusion that it was of such exceeding tenuity that it did not extend sufficiently far from the silicious frustule to indicate its presence at all. But the dye took at once on the diatoms, and on every other particle of matter, vegetable or otherwise. The only inference I drew from this experiment was that the aniline paralyzed instantaneously the

life function of whatever protoplasmic coating that might have previously given rise to the power of locomotion in the frustules.

It then occurred to me to test the effect of the aniline as a means of differentiating the diatoms, the strong and robust, as well as the hyaline forms, which are sometimes nearly lost to view in balsam mounts. For this purpose I allowed a liberal amount of the material to remain in a concentrated solution of aniline for a period of five hours, when I washed them repeatedly in changes of water until no more color was evident in the fluid removed. The result of this staining has furnished me with a wide range of interesting data, fairly recorded in a mount forming a part of the whole series of slides made to accompany these notes. Notably among the phenomena presented may be mentioned that on the slide may be seen numerous large, solitary specimens of *Navicula viridis*, and specimens of a smaller size of the same grouped mostly in fours, adherent together, and others by twos alone. In addition to these there are many specimens of *Eunotia*, *Fragillaria*, *Navicula radiosa*, and other smaller forms, all showing an elegant amethystine color by daylight and a reddish violet by student's-lamp light, and demonstrating that the stain had taken satisfactorily. This staining with aniline violet differentiated certain structures that would not have been modified in balsam mounts. The living diatoms, dried on the slide and covered with balsam, present the endochrome in a uniform layer of color, filling the whole internal part of the frustule, in the various shades of green, olive green, or brownish hues. Whereas, with the aniline stain, the endoplasm has been rent asunder and driven to the side walls of the frustule, and is there densely stained and banked up against the separating walls of the quadruple-grouped diatoms, there being a distinct hyaline or clear line of siliceous separating the frustules where in contact, thus differentiating separately the collapsed endoplasm of each separate frustule. This action of the aniline on the larger frustules was identical for all. But on the smaller forms the endochrome is merely indicated by two central patches highly stained, with a clear bisecting line of silica separating the two masses of endochrome, the sides of the frustules also showing hyaline borders internally. I said above that there was no appreciable thickness of the layer of exoplasm on the frustules, yet it is evident, by the

frustules taking the stain in such a dense and beautiful manner, that there must have been an infinitely thin layer of protoplasm, which appropriated the dye. My reason for this conception is, that in the two slides of the Montgomery, Ala., fossil fresh-water earth, which also form a part of the series of slides, the silica, no longer having any plasmic coating, refused to take the aniline dye, except in a manner to be referred to further on, the plain surfaces separating the lines of ribs being almost devoid of any show of stain. The above is about all of interest that I could determine as to the effect of an aniline dye on the living frustules.

The bottles containing the living diatoms from Whistler, as well as the fresh brackish-water material from Mobile Bay, were allowed to remain over-night on the mantel near the window. On the next morning I observed the contents of the two bottles with a band lens, and noted that hundreds of the Whistler diatoms had left the sediment and algæ at the bottom, and were travelling around near the line of the surface of the water in the bottle in preference to any other part of the sides. At this moment I recalled the common statement that diatoms, as well as desmids, will congregate at the lighted side of the vessel holding the mud with which they are mingled. To verify this I successfully used the following expedient: Thrusting the bottle previously described tightly down into a parlor match-box, I cut a hole in the paper of the box, a quarter of an inch in diameter, at a point about the middle height of the fluid, and on the reverse side I cut a similar hole, taking care not to detach the pieces of paper, so that they might be opened and shut as little windows, so as to admit transmitted light through the fluid on subsequent examinations. Having done this, I excluded all light from every part of the bottle, except from the central quarter of an inch hole. When this was done I exposed the bottle to the diffused light of the day, toward the south, and at convenient intervals during the daylight, for the balance of the day, I observed such changes as went on at the orifice admitting daylight.

The first phenomenon of interest, after about one hour's exposure, at about 9:30 A.M., was that the diatoms had already congregated at the spot of clear glass in fair numbers and were travelling across the field in all directions, with an easy, steady, direct motion. There were also groups of the "tetradelphia"

N. viridis, and the single larger *N. viridis* was seen. But the most unexpected thing noted was that seven Cyclops and Cypris, and the young of the former, had gathered at the light spot. In a moment the Cyclops scattered, but the Cypris kept on its lively feeding and remained constantly within the spot admitting the light. At other intervals during the day the Cyclops could always be seen playing around or darting across the light spot, and early in the day a few desmids appeared attached to little strands of algæ, and also a few large desmids—*Micrasterias rotata* and *Closterium moniliforme*.

At a time when the diatoms were noted as being quite abundant, I arranged the microscope by bringing the tube to a horizontal position, and placed the bottle upright between the thin metal stage and the substage. I then was enabled to observe the travelling motion of all the diatoms congregated within the radius of the quarter of an inch circular opening admitting the light directly through the centre of the liquid. A Beck & Smith half-inch lens gave a sufficient magnification, of, say, two hundred diameters, enabling me to view all of the diatoms, large or small, while in active motion. This method of examination has the advantage that the diatom is in actual contact with, and is adherent to, a smooth glass surface, and, as its movement progresses in a straight line for the whole distance of a quarter of an inch, the rate of movement can be timed by a watch. As this was relatively slow, it will be needless to state how many seconds were consumed in traversing the width of the opening. And as there were quite a number simultaneously crossing, there seemed to be no interruption to a continuous direct motion, as would happen when a slide is examined in a horizontal position and the field littered with particles of débris. When such is the case the direct motion is usually interrupted. An obstacle intercepting the path of the diatom causes it to reverse its propelling power, whatever that may be. But in the bottle there was no débris adhering to the sides, and the only obstacles to be encountered were other diatoms travelling at will in the general field. The desmids were never adherent to the glass, for if the bottle was held in the hand on any occasion they were always in a tremulous state, chiefly attached to minute threads of algæ, while the diatoms kept up a constant motion, always in contact

with the glass, while being examined with a moderately high-power hand lens.

This movement of the diatoms in contact with the smooth interior surface of the glass bottle will, I think, not yield to any other interpretation, except that the gelatinous character of the enveloping protoplasm permitted them to adhere safely to the glass without impeding their motion at pleasure; and this is probably why there was little or no evidence of the jerky or retrograde motion often seen in a restricted field, as would appear under a one-sixth lens.

The facts developed here, and in the preceding account of the motility of *Amphiprora ornata*, I propose to utilize in the closing portion of these notes, when I will present my argument in favor of the plea that the diatom has as much right to be regarded as a protozoan as any of the other already acknowledged rhizopods. I return for the moment to note additional studies of the character of the motion of the large *N. viridis*. While contemplating the movements of a large specimen, I kept the diatom constantly in the field to test even a suspicion of any sheath or protoplasm covering. Noting very closely its perimeter, I was able to distinctly make out that the diatom was surrounded by a barely perceptible aureole, its outline being indicated by a row of three or four minute particles of débris—not bacteria. These remained continually at a permanent line close to one edge of the frustule, leaving a hyaline space separating them from actual contact with what would be regarded as the silicious edge of the frustule. While still keeping my attention fixed steadily on this line of minute débris, additional particles were gathered and took their position in line with the others. But for this phenomenon it would have been practically impossible to differentiate the extension of the gelatinous and pellucid covering from the surrounding water.

On another occasion I watched the action of drifting bacteria and other particles passed during the transit of the diatom. These were constantly drifting by, either above or under the frustule. Eventually the progress of the diatom was stopped for a few moments by collision with a mat of débris, when a large, motionless, gelatinous globule was arrested at its free extremity. At the moment I recognized that the globule was under and in

contact with the diatom, and about half-way freed from its end. Now, while the diatom was at rest, the globule, without any motion of its own, was transported back to a point under the central nodule of the diatom. After resting there a moment it was carried back to the free end of the diatom. Meanwhile the diatom freed itself from the obstruction, and the globule was liberated, and I then again saw that the globule was inert and incapable of motion of its own. Therefore it is reasonable to suppose that its motion was due to a propelling influence exerted over it by the exoplasm of the *Navicula viridis*.

With regard to the momentum of the diatom in motion, I saw a rapid traveller, a small *Navicula radiosa*, forge along and strike a large, quiet *N. viridis* about the middle, with such an impetus as to throw the *N. viridis* through an arc of more than forty-five degrees to the left of the point of impact. It immediately regressed after the shock. The mathematical physicist could tell the nature of the impact—as impact is a resultant of weight and velocity, and motion is the opposite of inertia, one indicates life and action, the other inability to change position without some extraneous force.

Still drawing upon my study of the Whistler fresh-water gathering, I examined closely the behavior of the “tetradelphia” groups of Naviculæ. I observed that the quadruple brotherhood of so-called single cells could turn around in their own length, that they could also travel in straight lines, and that if capsized or thrown on their “beam ends” they struggled to bring themselves to the normal position of bodies swimming horizontally. While they were struggling to regain the plane of flotation I was enabled to study them in every aspect. In these frustules the characteristic endoplasm, endochrome, oil globules, vacuoles, etc., were clearly seen, more particularly through the cingula, or connecting band, as this is less lined than the frustular faces. This combination of four frustules would seem to suggest that the directive force of the quadruple frustules is controlled largely by the two external frustules, and for the four to move in a direct line the protoplasmic, propelling force (?) must be synchronous in all four; and when it is not so, or when the quadruple frustules are moving in a circle of their own length, the rapid, undulatory vibrations of the protoplasmic sheath of the two

outer frustules must certainly operate inversely to each other, or are not, at least, synchronous and impulsing in the same direction. This is merely suggested as an hypothesis of cause of motion.

As expanding further the subject of motion in the diatom, I will offer another phase that may have a useful bearing on certain of such hypotheses long in print and subject to revision. At another time, while seeking clues to the presence of the protoplasmic covering, I followed a large *Navicula viridis* in its movements through the water, as seen in the field of the microscope, the slide being uncovered. In the wake of the retreating end of the diatom there appeared to be a form of attractive suction over minute particles along its line of transit. A train of minute particles lagged along after the passage of the diatom, at a distance to the rear of about the width of the diatom, until the attracting power had ceased to act, when they would become still. The particles were drawn in semicircular arcs from either side of the axial line of the diatom's passing range, the axial line being tangential to the opposing arcs of motion of the particles following in the wake of the diatom. It would have been impossible for this movement of particles to have taken place if the motion of the diatom was caused by the expulsion, at any time, of infinitesimal jets of water. Likewise it offers an insuperable objection to the theory of motion accredited to Prof. Hamilton L. Smith and quoted from Wolle's "Diatomaceæ of North America": "that the motion of the Naviculæ is due to injection and expulsion of water, and that those currents are caused by different tension of the membranous sac in the two halves of the frustule," etc. Wolle also quotes Cornelius Onderdonk as ascribing the movements of diatoms to "a thin fluid mass in rhythmical motion," which Onderdonk had elsewhere proved to his own mind by experimental dyeing tests: "The fluid rhythmical mass covered the surface of the diatoms." I looked up the original communication of Onderdonk and read it. While his experiments were very interesting, he had made no reference whatever to the power of the protoplasmic layer to capture and tenaciously hold and transport, at its own volition, appreciable masses of living particles.

It may not be inappropriate to introduce herein a transcript of

Rev. W. Smith's views in regard to the motion of diatoms, quoted in Carpenter, edition of 1856: "Among the hundreds of species which I have examined in every stage of growth and phase of movement, aided by glasses which have never been surpassed for clearness and definition, I have never been able to detect any semblance of a motile organ, nor have I, by coloring the fluid by carmine or indigo, been able to detect in the colored particles surrounding the diatom those rotary movements which indicate in the various species of animalcules the presence of cilia" ("Synopsis of British Diatomaceæ," Introduction, p. xxiv.). This quotation would also seem to indicate that the Rev. W. Smith was not acquainted with the peripheral motion of the protoplasmic layer of *Amphiprora*, for if he had been acquainted with this he would have had to modify the above opinion and substitute a form of motility independent of any easily seen ciliary processes.

The theory which the sum total of my experience so far suggests is that the motion is probably caused by an infinitely rapid undulatory motion of the protoplasmic sheath, which I assume to exist, covering the diatom on all sides, which vibratory pulsations are too minute to be seen under any degree of magnification, and whose reactionary beats against the water cause the forward or retrograde movements at the instinctive will of the diatom.

Returning to the theory of propulsion advanced by Prof. H. L. Smith, and with all due regard for his long and signal experience in the study of living and other diatoms, I would respectfully call attention to some points calculated to weaken, or even vitiate, the claims of any expulsive action connected with a median diaphragm separating any two frustules that are united and in motion. The quadruple frustules are fairly quick in their progression. Were the hypothesis actually true for a single individual, we would, in the quadruple instance, have four frustules propelled by two exterior sides, and eight opposing prows, leaving the three central enclosed walls in "innocuous desuetude" until each frustule was allowed to shift for itself.

Before finally disposing of the question of motion of diatoms, I would like to advance two more points of interest bearing strongly upon the subject. In the brackish material containing *Amphiprora ornata* there were numerous specimens of *Navicula Smithii*. I gave some attention to one of these, and if the rela-

tively slow motion of a *N. viridis* can interest and hold the attention, this interesting form must in a higher degree give cause for admiration. Conceive a beautiful, strongly lined, golden-hued oval rushing through the water with a speed outdistancing all other forms that I have ever seen in motion. When this is seen it is almost impossible to disassociate the idea of a strongly pulsating life and animal energy from this little creature. To call it a "simple lowly plant" would be to treat it with a presumptive indignity. If one were permitted to speculate as to the character of its motion, the mind might conceive of vibratile pulsations as swift as the undulatory waves of light, or as the rapid alternations of the electric arc current in producing its light, if we take into consideration the diatom's minute size and its energetic progress through the water by the imagined pulsations of its invisible protoplasmic sheath.

Lastly, in relation to another character of motion—that of the *Bacillaria paradoxa*. When we have seen that the ribbon of conjugate frustules is brought to a straight line with terminal frustules, taking the order of "right dress," and that suddenly the end file leader darts off at a rapid stroke to the end of its neighbor, and that the others do the same in quick succession, until the whole line or group have passed each other, and then repeat the same movements in a retrograde manner, we have viewed a life movement of the most curious interest and truly paradoxical in its nature. If we carefully analyze the consequences of these successive phases of motion, we are forced to admit that each frustule has a sheath of a colloid or gelatinous character (somewhat like the coleodermis of De Brebisson) that allows the contiguous sides of each frustule to coalesce or anastomose and separate with equal facility. If this were not the case they could not live in collective communities. These facts substantiate, without staining or other experimental expedients, the truth that this diatom, and possibly all diatoms, are invested with a protoplasmic mantle imbued with life, and capable of being paralyzed or killed instantaneously by staining agents, and that this protoplasm has some of the characteristics of the protoplasm of the protozoa.

In the brackish material I witnessed a small *Amphora*, quiet and motionless, upon the flat surface of which a bacterium seemed to

be struggling to cross its body, being apparently held by the resistance offered by the protoplasmic layer of the *Amphora*. It is well known by those who have made a study of the simple *Bacillus leptothrix buccalis* of the teeth, that if these are taken directly from the teeth and put in a small drop of violet ink, and a cover glass placed over them, their power to travel will be evident. They move along in a kind of scintillating way, and change their position moderately fast while being observed, so that there is no need of mistaking a bacterial movement for what is known as the Brownian movement of powdered or finely divided inert or mineral particles. The bacterial movement has a distinct and peculiar character. The bacterial form alluded to as traversing the surface of the little *Amphora* was evidently under the restraining influence of a power lodged in the external covering of the *Amphora*. I did not, however, follow it until it freed itself from the *Amphora*. I may remark that this closes an interesting variety of experimental and ocular evidence bearing on the character of motion in the diatom, and also of its protoplasmic surface.

Resuming the thread of my study of the diatoms in the bottle of material from Whistler, Ala., late in the evening of the fifth day of my experimental studies, giving the final examination to the condition of the diatoms at the spot admitting daylight, I was surprised to find that during the interval since I had last examined it exactly fifty desmids had come up and fixed themselves in the illuminated area of one-quarter inch diameter. These were all of one species—*Micrasterias rotata*. The diatoms still had life. But on the next morning—the sixth day—I found that all of the desmids had dropped back into the sediment and were no longer visible, and that the diatoms were all dead and glued to the sides of the bottle by what I took to be colonies of bacteria or some fungoid matter. A new class of life had usurped the territory in continuing the struggle for existence. Collaterally with the living Whistler diatoms, I studied occasionally the bottle containing the Mobile Bay brackish-water diatoms, and I incidentally observed that the rhizopod, *Arcella vulgaris*, was quite common on the sides of the bottle. From the same source I studied the movement of the living pseudopodia of *Difflugia pyriformis*. I was previously familiar with *Amœba proteus*,

but what struck me with most interest during a portion of the time was the presence of beautiful vorticellæ in the sediment at the bottom angles of the bottle. Above the sediment there appeared to be a silvery cloud of monad-like infusoria; and while viewing the vorticellæ with a powerful compound hand lens, the bottle being vertical, I observed that the coronal cilia of the vorticellæ, when expanded and revolving, produced a sort of whirlpool, into which poured a funnel-shaped stream of the minute infusoria. The vorticellæ were attached to débris, and were constantly whirling their cilia and retracting their soft, elongated body. The exuviae of dying infusoria or bacteria, even from the first day of securing the brackish-water specimens, were rapidly covering everything with a flocculent, ochreous pellicle, which accumulated so rapidly that on the fifth day all the vorticellæ were dead.

The cause of motion in the Diatomaceæ has eluded, so far, a direct and positive solution, and the endosmotic and exosmotic theory seems to be the most favorable hypothesis in the case. The idea of exosmose and endosmose action would occur spontaneously to any one studying the biological functions of the diatom. That there is, and can be, endosmotic action is demonstrated by mounting the dried frustules with thin balsam. The larger *Pinnulariæ* of the Mobile Bay brackish source have the major part of the air within the frustules replaced in a few minutes with the balsam; and this action of displacement of air continues for days after the slide is prepared. This is proved by the so-called canaliculi showing very clearly and distinctly the rib-like markings filled with air bubbles. (That these spaces are not canaliculi, but rather corrugations or flutings, I will endeavor to sustain when I reach the subject of my experiments in charging the markings of the diatoms with coloring matter.) Gradually, after days, there is a full and complete expulsion of all air from the frustules, provided the balsam is thin when first used. If the balsam is quite thick, and dries readily, the air will remain permanently.

In regard to the substances designated as endochrome, chlorophyll, and a substance, derived from the chlorophyllaceous matter of the diatom, known as phycozantina, I have thought it proper to suggest that the contents of diatoms are not identical with the chlorophyll of the desmids or of the leaves of plants, but

are characteristic products of the feeding of the living diatoms among the water plants, or other sources of food supply peculiar to their habitat. I would advance the following, bearing upon the subject, viz.: If the diatoms are expressed from the common green algæ of springs, or slimy confervæ of ditches where the plants are exclusively green, the endochrome is mostly of a dull or bright green, and even emerald green. But the student of the Diatomaceæ is also, almost always, taught to seek for them wherever moist surfaces are covered with a rusty or ochreous color. It is certain that a brown or ochreous color is not indicative of chlorophyll, as the name itself means the "green of a leaf." On the contrary, the contents of the living diatoms derived from brackish mud are mostly brown, or possibly olive brown. While one is contemplating diatoms containing brownish contents, he will also note that the associated vegetable débris in various stages of decay is also brown and matches with the color of the endochrome. So, then, the color of the endochrome is probably a result of the character of the food supply found in the local habitat of the diatom, and it may be a product of morphological assimilation and digestion. On examining certain species of *Surirella* on the Mobile Bay slides, emerald-green stains may be seen at the wedge-shaped end of the frustule, while the balance of the frustule is colorless; but the slides also illustrate brown- or green-colored contents of various shades in extreme profusion.

Having, to my own personal satisfaction, witnessed the indisputable evidence of an intelligence in three representative species of three genera of the Diatomaceæ, and having stated in plain terms the manner in which the proof was adduced, and which is duly capable of verification by any one who will take the trouble to review and corroborate the facts and phases established by my experiments, I will now endeavor to make an expansion of these biological phenomena, to draw attention to the fact that any diatomist, expert or amateur, who sees fit to regard the diatoms as belonging to the protozoa rather than to the unicellular plants, can feel some satisfaction in his own mind, notwithstanding all that is upon record excluding the diatoms from the lowest order of the animal kingdom. This inclination with me has been the outcome of accumulated experience in the study of the

Diatomaceæ, as a purely scientific pursuit or pastime, for the past fifteen years. If the aggregate result of one's efforts in any line of study is of any value, it certainly entitles him to enter the field of generalization, if he finds a reasonable or substantial basis to induce such action.

To within about a year ago I felt satisfied with the commonly conceded position of the Diatomaceæ among the unicellular algæ, and assigned them to the vegetable kingdom in preference to the animal kingdom. Less than a year ago Dr. Arthur Mead Edwards, in a letter to me, propounded the query, "What is a diatom?" and also answered his own question by saying, "I believe that the Diatomaceæ are the Protista." Through an impolitic impulse I replied that it would scarcely be possible to admit that the diatoms were other than "unicellular plants." When, in order to substantiate his conception of their animal characters, he announced in a microscopical journal that he had actually seen the animal occupant of a frustule of *Coletonema eximium* leave and re-enter its shell on several occasions, I wrote him that the species of that name were so small that it would seem hopeless to take that view of one of the smallest among the genus *Pleurosigma*. When we mention the name of this eminent physician, who has devoted forty years of his life to the study of the Diatomaceæ, and who might justly be styled the Nestor of American diatomists, he must be credited with valid reasons for refusing to accept the diatoms as single-celled plants, and for using his abilities in opposition to the continuance of such a view.

I would feel better satisfied to have the station of the Diatomaceæ removed from the domain of doubt which surrounds their position, by irrefragable proof. I would be more contented in realizing that this special class of animated matter was ranged with animal life rather than with plant life. It would tone down and remove from the realm of triviality the enthusiasm of those whose mind has become captivated with the beauty and mystery attached by the Creator to this mystical unit of the universe. If genius could demonstrate beyond cavil the animal nature of the Diatomaceæ, then one would find the objects of his favorite study placed a scale higher than the simple Amœba and in near relation to the beautiful Radiolaria. Who will undertake to explain why the Diatomaceæ so strongly appeal to intellectual

minds? Upon what common grounds of interest have clergymen of all denominations, soldiers, physicians of the cultured races, and many others who were gifted with the naturalistic instinct, been incited to connect their names and fame with a perpetuation of the study of this department of invisible nature, if not through that natural bent which impels the intellectual faculty in certain individuals to an eternal expansion of the philosophical spirit or the conquest of abstraction over matter, space, and time?

Passing to the staining of living diatoms, I will refer to some results accomplished by a few experiments. Having already tried the diatoms derived from a fresh-water spring, I thought proper to extend the process to some fossil fresh-water deposits, on account of their richness and the large size of the contained species. I selected for trial an ounce or two of the fossil fresh-water deposit, discovered by myself two years ago, occurring at Montgomery, Ala., being the most conspicuous deposit of fresh-water forms found in the Southern States.

This deposit contains the largest and most beautiful variety of *Pinnularia nobilis*, whose form was not yet known up to the date of publication of Rev. Francis Wolle's "Diatomaceæ of North America," and, therefore, is not shown in that volume. While employed as draughtsman of the machine shops of the Mobile & Ohio Railroad Company at Whistler, Ala., five miles distant from Mobile, I daily made an extensive use of chemicals in preparing paper for the "blue copying process." I was prompted to use the bath of this process for staining the diatoms. The proportions are these: To an ounce each of red ferriprussiate of potassium and ferrocitrate of ammonia add four ounces of water. The two ounces of diatomaceous earth were boiled in a strong soap solution for an hour or more. Then the boiled diatoms were washed in repeated changes of water to remove objectionable débris and traces of alkali—as the alkalies discharge the blue color of the stain. The diatoms were then freed of water, and decanted on a piece of common blotting paper to remove the remaining water. In this state they were transferred to the "blue process" liquid. The material, in small quantities, was poured on common china plates, and constantly moved about until the liquid and diatoms were spread as a thin layer over the whole surface of the plates, and then exposed to the direct rays

of the bright sunlight for a quarter of an hour or longer. When the rays of the sun had acted sufficiently upon and had thoroughly dried the diatoms, the next step was to recover them by washing the material in pure water and collecting the residuum together again. The experiment proved successful, and the diatoms were seen to be duly stained a beautiful light shade of blue.

I next mounted a slide in balsam and viewed it under the microscope, and was well pleased with the result. The internal corrugations held the stain, differentiating the various markings in a moderately satisfactory manner, and gave the frustules a far better appearance than when unstained. But, not being fully satisfied with the effects of the blue stain, it occurred to me to restrain a portion of the material already stained blue. Before having accomplished the blue staining I feared that it would be a failure, and thought to substitute aniline violet for the blue liquid. Taking a pipette, I deposited a quantity of aniline into the blue liquid containing the diatoms, when I observed that the liquids would not mix, but the aniline at once gathered in round drops. Failing in this, I drew off all the blue staining fluid from the diatoms and removed the moisture by decanting again on blotting paper. I next put the diatomaceous mass into pure aniline, and allowed it to be immersed for about five minutes or more. I then removed the excess of aniline dye, and washed the diatoms in repeated changes of pure water until no more stain came off in the water. I then dried the stained material and mounted a slide in balsam. When I submitted the violet-stained diatom slide to microscopic inspection I was pleased at my success, as there was in many frustules a perfect differentiation of all markings of every character; the punctate striæ of *Cymbella*, the pinnulæ of all the *Pinnulariæ*, and the ribs of *Surirella*, were, in many cases, so perfect that every individual rib could be easily counted, the markings called canaliculi, or costæ, having the appearance of a dark, short line with distinct semicircular ends, each perfectly differentiated from its neighboring rib by a delicate, clear line of silex showing no stain; nor was the median smooth surface, divided by the raphe, stained, but the lines of the raphe and its terminal dots were filled with color.

I offer this as my view of the staining: The internal chemi-

cal deposit of the blue stain had thrown down or coagulated the aniline wherever the blue stain had taken effect. Otherwise, where there were no markings visible on the frustules, as on the smooth median surface divided by the lines of the raphe, there was no stain worth noticing. The raphe was in many cases well differentiated, as well as the two central nodular and two terminal dots of the larger *Pinnulariæ*. These two stained slides were the only ones made to test the possibilities and advantages to be derived from staining. As they have given admirable results, it adds another kind of interest in the study of diatoms. Had the material in the slides containing *Amphiprora ornata* been stained either blue or violet, the *Amphiprora* therein could have been readily located on the slides, but in the undyed state they are extremely hyaline and somewhat difficult to locate in balsam mounts under high powers.

The two stained slides were prepared for the series illustrating these notes. In connection with these two slides it may be noted that there is little affinity on the superficial surface of the fossil diatoms for the dye, but the external surface of living diatoms, after drying and mounting, indicates that such surfaces absorb and retain a perceptible amount of dye, which fact suggests that the external layer of protoplasm must have retained it. On an examination of the frustules in the slide stained by the compound process, it will be noted that there is an indication of coagula of the dye adherent to the frustules, while this appearance is entirely wanting in the Whistler fresh-water living diatoms as stained with aniline alone, and in the blue-stained fossil diatoms from Montgomery, Ala.

If my language has been clear, it will be understood that the salient feature of this article is that the diatom is endowed (possibly all diatoms) with two non-interfering motions, qualities indicative of life—namely, the direct and retrograde, which is the generally known and universally acknowledged motion of the whole frustule, single, double, or quadruple, and also the subjective motility of the exoplasm or protoplasmic covering. The principal characteristics of this latter motion have already been given. This claim is, however, not advanced in the case of the discoidal forms, found adherent by countless thousands to marine algæ and the leaves of *Valisneria*, such as *Arachnoidiscus*,

Actinocyclus, *Coscinodiscus*, and *Biddulphia laevis*, which appear to pass their life cycle attached to water plants. But we also know that millions of the travelling frustules are removed from water plants which, when dried, exhibit the frustules in illimitable numbers, as may readily be determined from the mass of moss-like water plants sent herewith to the Society for distribution to such members as may desire to study them in the dry state.

Now, I would suggest that the character of the subjective motion of the protoplasm of the diatom possibly has its homologue in the cilia, pseudopodia, and other admitted protoplasmic appendages of the true Infusoria, and the Rhizopoda, and, in fact, the Protozoa generally; that is to say, in a contractile and extensile power common to the lowest forms of microscopic animal life. Since the activity of the protoplasmic sheath of the *Amphiprora ornata* is now clearly pointed out, it is within the range of verification by the simplest means. One is certain of witnessing a phenomenon that has for many years been of mysterious interest to observers. But there are two kinds of protoplasm, that of plants and that of animals. And the simplest in structure of the animal protoplasms is that associated with the Rhizopoda, which, barring the nucleus, are structureless, gelatinous masses, having an inherent extensile and retractile power, and presenting various modifications of outline. When employed in seeking their food, then their characteristics are best shown and appreciated.

Amæba proteus offers us protoplasm in one of its simplest conditions, that is, where it is devoid of the power of secreting a mineral covering, or even the rudiments of an internal skeleton. From this simple stage protoplasm passes through rising grades of complexity, ending in its power sometimes to secrete a chitinous covering, and sometimes a silicious shell or a shell built up of grains of silex. There is also the simple, structureless protoplasm of the Foraminifera, which is endowed with the power of secreting a shell from calcareous sources, and that of the sponge, which exercises the power of assimilating the molecules of carbonate of calcium or silica disseminated in the fluids of its habitat.

To further expand the relation between animal protoplasm and its peculiar power to secrete silica, I will offer my illustrations

from the domain of the Protozoa. I have consulted as many sources of information as the limited literary resources of my surroundings would admit.

First of all, possessing a copy of Joseph Leidy's "Rhizopods of North America," I consulted that for a portion of my data. In the said monograph is a general account of the classification of the Protozoa and their characteristics, as adapted from the great work of Prof. Haeckel. In this I find that, of the true Rhizopoda alone, the following species are characterized as having a protoplasm capable of secreting silicious shells, skeletal coverings, or external appendages—viz., *Euglypha alveolata* and *Euglypha olex*; *Clathuralina elegans*; *Acanthocystis* (minute silicious spicules); *Challengeria* (single-celled silicious organisms); *Acanthometrina* (having its spicules arranged in geometrical patterns, such as might be developed in a space of three dimensions, or on the surface of a sphere, and, owing to their extreme delicacy, collapsing or falling apart on drying and handling, and which were apparently only found in the material dredged by the *Challenger*); and also the *Thallasicola*, together with the numerous genera of the Radiolaria.

In connection with these I would refer to the fact that the peculiar open-meshed and stellate silicious skeletons known as *Dictyocha*, hitherto classed with the diatoms, likewise the forms called *Eucampia*, are stated in Wolle's "Diatomaceæ of North America" to be no longer regarded as diatoms, but are excluded therefrom. This dictum would relegate them to the Protozoa. But they are nearly always present in recent as well as fossil diatomaceous earths, as I have put upon record in the JOURNAL of the Society in some remarks upon a small *Navicula didyma* overlapping a *Dictyocha fibula* in the body of a *Coscinodiscus* from the Tampa fossil earth slide, filed with and donated to the Society. What expert diatomist will undertake to clear up the puzzle presented by the fifty or more discoidal forms on the same selected slide, exhibiting, either upon or through the internal structure of the diatom, hundreds of minute diatoms of many distinct species held therein? How did they get there, and why was the selection limited exclusively to the minutest of forms? Has any one, up to the noting of this peculiar characteristic of the discs of the Tampa marine fossil earth, made any observation of a similar con-

dition in the fossil deposits of any other known region of the globe? Notice also the power of the Foraminifera to secrete calcareous shells, and of the Spongidæ to secrete calcareous spicules, and we can infer that the animal protoplasm of the Protozoa has the power to elaborate out of their surrounding fluids the necessary shields or frames best adapted to their vicissitudes.

Against all of these positive and convincing data we can contrast nothing of an analogous kind in plant life. It would be useless to refer to the power of certain plants that flourish in ditches and marshes, and in tropical and semi-tropical regions, as the *Equisetaceæ*, or the canes, bamboos, and cereals, whose cuticular surface is a layer of vegetable silica. I believe that there is not any analogy between the power of the protoplasm of the Diatomaceæ to assimilate oxide of silicon as an integral part of its life, and the power of the plants named above to secrete whatever silica there may be in their woody structure; while there is abundant evidence of the animal protoplasm having in an eminent degree, and almost exclusively so, the power to appropriate from fresh or salt water the requisite silica needed in its life cycle.

But what has already been adduced does not reach the inferential bounds of the subject. Convictions often arise from fortuitous sources to round up a final conclusion. And as the diatomist accumulates fresh experiences year by year, he may group his facts in aiding him to some final conclusion or to reinforce some special view.

It is at this stage of the inquiry that the question comes up, Why is it that in nearly every known marine fossil diatomaceous deposit the silicious skeletons of the Diatomaceæ form the major part of the deposit, with few exceptions? The main exception is where the proportion of the diatoms in the deposit is less than the other fossil organic remains derived from the recognized rhizopods. What construction and interpretation are we justified in putting upon the fact that when we analyze any given fossil marine deposit we invariably find the following derivatives of the Rhizopods, viz., silicious Polycystinæ, or more properly Radiolaria, silicious sponge spicules, and silicious Diatomaceæ, together with calcareous foraminifera, invariably, or at least with few exceptions, associated in deposits of extraordinary thickness? Of two of these typical deposits I can justly claim that, at the

date of writing these notes, I am more familiar with two marine fossil deposits, discovered by myself, than any one else who has made the study of the diatoms a specialty. In one of these the Polycystinæ predominate above the Diatomaceæ, sponge spicules, and Foraminifera. This is the St. Stephens, Ala., eocene deposit, of which this Society possesses selected slides. Yet the diatoms are very abundant therein, and of many species. The other is the marine fossil deposit existing in the Florida phosphate rock area around Tampa, Fla., wherein the Diatomaceæ predominate above the Polycystinæ and silicious sponge spicules, and where calcareous Foraminifera seem to be entirely absent. The egg-shaped or ovoid silicious gemmules of sponges (?) are also very abundant therein. Taking an example right at hand, the world has been supplied with cleaned diatoms from the harbor clays and muds of Mobile Bay, in which are always associated diatoms, a few species of Polycystinæ, silicious sponge spicules, and rhizopods of several species, and more particularly the silicious shell-building ones known as *Diffugia pyriformis*, *Arcella*, and others. The silicious bodies called *Dictyocha* also abound, and the marine Foraminifera which secrete calcareous or chitinous shells. The mineralized calcareous cementstein of Sendai, Japan, and of the islands of Mor and Fur, situated off the northern coast line of Europe, when dissolved in acid, yield masses of Diatomaceæ, sponge spicules, and Polycystinæ, the diatom in the several cases predominating. The fossil diatomaceous clays of the Atlantic seaboard, from Southern New Jersey to Charleston, S. C., at Richmond and other points, always yield a small proportion of Polycystinæ in combination with a tenfold percentage of the Diatomaceæ. The fossil deposits of the Californian coast line yield diatoms in combination with Polycystinæ and sponge spicules, and so on *ad infinitum*.

Passing from the fossil marine deposits which I have put upon record, I will mention two extensive and rich deposits of freshwater origin. First, the lacustrine fossil deposit at Montgomery, Ala., where billions of sponge spicules are associated with a stratum of diatom frustules over twenty feet in thickness and of extraordinary extension. Second, the marine marsh fluviatile deposit found by myself a year or so ago about a mile north of Mobile, on the western bank of Mobile River, which deposit is

characterized by the extraordinary richness of its diatoms, silicious sponge spicules, and billions of silicious rhizopod shells, *Diffugia* and other species.

At this point it might be appropriate to allude to a deposit situated at Montgomery, Ala.—the great artesian basin, about fifty feet in diameter and at least fifteen feet in depth. During a visit to Montgomery I observed that the basin was being cleaned out and that laborers wearing rubber boots were bailing out the ooze that had accumulated at the bottom, which ooze was at that time about eighteen inches deep and of about the consistence of gruel. Desiring to ascertain whether the ooze was a diatom ooze, I secured a quantity of the material and sent it to Mr. C. L. Peticolas, who sent me back beautiful slides of a pure gathering of *Epethemia gibba*. He remarked that it was the prettiest gathering he had ever seen of that species, and likewise the hardest to clean. Associated with the *Epethemia gibba* were a few species of smaller diatoms. This basin has been a feature of Montgomery, Ala., for over fifty years, and it is a remarkable fact that the basin held but one conspicuous species of diatoms through so many years.

As a last resort to defend the thesis that the Diatomaceæ ought to be regarded as belonging among the lower orders of animal life rather than among plant life, we can bring to our aid the established rules of the logician and of the mathematician; the former granting the use of the syllogism, and the latter that of the "theory of probabilities," either of which I believe would force the solution of the question in favor of an animal status. The fact that the earliest algologists had classed certain genera of the filamentous diatomaceous groups among the Confervoideæ, such as *Melosira*, *Schizonema*, *Homeocladia*, *Mastogloia*, etc., on account of their algaceous habit, does not necessarily compel those to fall into line with their views who choose to regard all diatoms having a distinctive motive power and a motile protoplasmic sheath as belonging to the Protozoa.

Besides Leidy's excellent work, "Rhizopods of North America," I have consulted the able articles of various specialists in well-known encyclopædias, and I am under especial obligations to the paper of the eminent diatomist, Count-Abate Francesco Castracane, entitled "Generalita su le Diatomee" (1884).

I have also consulted the article by Prof. H. L. Osborn, entitled "The Protozoa—a Phylum of the Animal Kingdom considered Biologically" (*American Monthly Microscopical Journal*, October, 1892), and the presidential address by Mr. Charles F. Cox, published in the JOURNAL of this Society, January, 1892. I have not had access to the recently published work of Messrs. Frederick W. Mills and Julien Deby, "An Introduction to the Study of the Diatomaceæ" (London and Washington, 1893), so that to this fact must be attributed any lack of acquaintance with the theories which may have been lately proposed.

Before closing I fain would refer to the use made by certain animals of the Diatomaceæ as a part of their food supply, with the view of determining whether the nourishment adapted to carnivorous animals is made up of microscopic plant protoplasm, either of what is called the ectosarc or endosarc of the Diatomaceæ. The most striking example within my own experience is that source of the Diatomaceæ derived from the gizzard or craw-like organ of the mullet of the Gulf bays. From such gullets I have secured hundreds of pear-shaped pellets which were literally masses of pure diatoms, and of which I sent many in exchanges, both to foreign countries and also to Mr. C. L. Peticolas, of Richmond, Va., who returned to me at times beautiful preparations of the same. I have never found anything else but diatoms and sand grains in these fish gizzards, so this, as far as my experience goes, was the only food supply preyed upon by the mullet. I have also demonstrated that the desiccated excrementitious matter left by sea gulls on clusters of pilings in Mobile Bay has been a rich source of marine diatoms, after the undigested particles of fish bones, etc., are dissolved away with acid. As the diet of the sea gulls is principally fish, we can readily account for the presence of diatoms in such a recent source as the living sea gull. The stomach of the oyster sometimes yields diatoms, but the green masses found in the stomach are preferably marine algæ. The digestive tracts of the sea cucumbers—Holothuriæ—have been justly celebrated for yielding immense numbers of marine diatoms. The trepang of the China Sea (which is dried abroad and sold in Mott street, New York, as a Chinese delicacy) is a sun-dried sea cucumber. From several sources we learn that in the Arctic and Antarctic regions

the Diatomaceæ float on the surface of the seas as a dense foamy sheet and are the sole food of some kinds of fish. The Abbé Castracane, already referred to, has written a special paper on the presence of the Diatomaceæ as the sole and exclusive food of *Echinus* and Echinodermata and Holothuriæ, dredged by the *Challenger* from depths of 2,000 and 5,740 metres. His object was to prove, contrary to common belief at that period, that plant life vegetated at a depth where the rays of the sun never penetrated. The fact of his finding rich masses of *Synedra thalassiotrix* Cleve. and *Coscinodiscus* in the Holothuriæ and Echini taken from these depths confirmed his belief. As the Abbé was a firm believer in the plant nature of the Diatomaceæ, he could not well do otherwise than regard this kind of food as plant life. He proved that the diatoms passed their life cycle at the bottom of the ocean, at 5,740 metres, on the feeding ground of the Echini and Holothuriæ, as the endochrome had not been removed by the digestive juices of the Echini or Holothuriæ after their removal by the dredge from their habitat at the bottom of the ocean, thus drawing another illustration of the use of the Diatomaceæ as a food supply.

I would note that at least four of the slides prepared from Mobile Bay brackish-water material, and sent herewith, show a number of rhizopods, *Euglypha alveolata*, within whose transparent and glass-like shells may be seen several varieties of very minute diatoms—viz., *Cocconeis pediculus* and *Naviculæ*. Also in a more pronounced manner, in the beautiful plates of Leidy's "Rhizopods of North America," various amœbæ are depicted at the moment of enveloping within their fluent protoplasmic layers large *Pinnulariæ* and other diatoms. And I have put upon record with this Society a selected slide of *Diffugia pyriformis* and other species, in which minute diatoms are seen to form a part of the solid shell covering the soft pseudopodial parts of the animal protoplasm when in its living state.

In the slides referred to above a pair of shells of *Euglypha alveolata* are mounted, showing the mouths of the shells in contact, or in the position usually regarded as that of conjugation. In the same slides will be noted an extraneous class of minute animals found in Mobile Bay—viz., minute shrimp, whose chitinous

cases have been turned a light hue of pink through immersion in balsam.

Before quitting the rhizopods I would make one more reference to an interesting feature that will have its application in summing up the consequences of these notes. I quote certain paragraphs in the article by Prof. Osborn, noticed above: "In its chemical nature the covering of *Hyalosphenia* is interesting, being *albuminoid* and less unlike the chemical nature of compounds in the protoplasm than are the skeletons of lime or silica found in *Rotalia* (foraminifera) *actinospherium* and many other specialized rhizopods. *It is, therefore, a less specialized act of the secretory power to produce a chitinous than a calcareous or silicious skeleton.*" And again: "*Liberkuhnia* is a naked body of rather definite outline, with one end prolonged into pseudopodia. The pseudopodia are never strictly radial, but are branching, the branches leading out into finer and finer divisions which often anastomose or join together. *The food is caught upon the network of pseudopodia and digested there.*" Or, in other words, we may put this interpretation on the concluding sentence, that an infinitesimal thread of protoplasm has a digestive, and as a consequence an assimilative, power. Can we not then inquire whether the living and moving protoplasmic layer of *Amphiprora ornata* has not an identical power, and is it not performing this digestive and assimilative function when it carries from point to point on its perimeter such particles as a motionless rotifer or a bacterium?

From the preceding restricted reference to animal life dependent on the Diatomaceæ, we are led to inquire whether an animal protoplasm would not be better associated with the idea of the sustenance of carnivorous animals, rather than that they should seek the sustenance of a purely plant protoplasm to build up and sustain their own changes of growth or waste.

This problem of the true nature of the sarcode of the Diatomaceæ is now respectfully submitted to those observers who care to take the pains to strive for a solution through observation, until no doubt shall remain as to what it is, whether absolutely plant or absolutely animal in its nature.

I would offer a few words explanatory of the contents of the six slides exhibiting the diatoms from the edge of Mobile Bay shore. They are prepared in duplicate, two of a kind, to show the

smallest species, the intermediate, and the largest discs. And the following genera are represented by from two to ten or more species each: *Achnanthes*, *Amphora*, *Amphiprora*, *Actinocyclus*, *Actinoptychus*, *Cocconeis*, *Cyclotella*, *Coscinodiscus*, *Campylodiscus*, *Cymbella*, *Epethemia*, *Eunotia*, *Gomphonema*, *Melosira*, *Nitzschia*, *Navicula*, *Odontidium*, *Pleurosigma*, *Steuroneis*, *Surirella*, *Synedra*, *Terpsinoe*, *Tabellaria*, the Naviculæ, however, being in the majority. In the observations of the living diatoms detailed herein I used a Zeiss D lens and at a magnification of about 600 diameters.

PROCEEDINGS.

MEETING OF APRIL 7TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twelve persons present.

Mr. Noah Palmer was elected a Resident Member of the Society.

Dr. Samuel Lockwood, who was expected to deliver the address announced on the programme, was by illness prevented from attendance. An informal session was held.

ANNUAL EXHIBITION, APRIL 19TH, 1893.

The Fourteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New York City, on the evening of April 19th, 1893.

Objects and apparatus, as noted in the programme below, were displayed in the large hall on the first floor of the Museum. At 9 o'clock REV. E. C. BOLLES, D.D., in the Lecture Room adjoining, gave an explanation of the projection of numerous microscopic objects on the screen.

PROGRAMME.

1. Water Wood-louse, *Asellus aquaticus*, showing the circulation of the colorless blood: by H. C. BENNETT.
2. Section of Human Scalp, showing hair follicles, sebaceous glands, and ducts: by H. C. BENNETT.
3. Transverse Section of a Cat's Tongue: by WM. WALES.

4. Section of Soap Bark, *Quillaya saponaria*, showing long prismatic crystals : by G. H. BLAKE.

5. Sulphate of Copper, shown by polarized light : by N. PALMER.

6. Coal. Vascular Cylinder of a Young *Stigmaria* : by F. W. LEGGETT.

7. Head of Tape-worm, *Tenia solium*, showing the Rostellum and Suckers, with drawings of the same. Also specimens of the Head in alcohol : by L. SCHÖNEY.

8. Butterfly Scales and Diatoms arranged in the form of a Vase of Flowers : by G. S. WOOLMAN.

9. Transverse Section of the Head of a Moth, *Utetheisa bella* : by L. RIEDERER.

10. Longitudinal Section of the Antenna of a Wasp, *Vespa maculata* : by L. RIEDERER.

11. Transverse Section of the Head of a Fish, *Atherina* : by L. RIEDERER.

12. Transverse Section of the Body of a Fish, *Atherina* : by L. RIEDERER.

13. Microtome, manufactured by Aug. Becker, Göttingen, Germany : by L. RIEDERER.

14. Selection of Serial Sections : by L. RIEDERER.

15. Young of Marine Crustaceans : by E. J. RIEDERER.

16-18. Bacilli of Asiatic Cholera : by J. A. GOTTLIEB.

16. From a Culture in Bouillon, $\times 1,550$.

17. From a Gelatin Culture, $\times 1,200$.

18. Cultures in Nutrient Gelatin in Various Stages of Development.

19. Human Blood, $\times 590$: by J. A. GOTTLIEB.

20. Blood of Seventeen-day Embryo Chick, $\times 480$: by J. A. GOTTLIEB.

21. Frog's Blood (stained), $\times 330$: by J. A. GOTTLIEB.

22. The Leitz Photomicrographic Apparatus : by J. A. GOTTLIEB.

23. Projection Apparatus, after Edinger : by J. A. GOTTLIEB.

24. Large Dissecting Microscope with Abbe's Camera Lucida : by J. A. GOTTLIEB.

25. Six Sections of Building Stones, shown on Automatic Re-

volving Stage by polarized light. Also specimens of the stones from which the sections were cut : by J. WALKER.

26. Polycystina : by J. WALKER.

27. Section of the Human Tongue : by C. S. SHULTZ.

28. Eggs of Various Insects, arranged : by C. S. SHULTZ.

29. Type Slide of Diatoms, arranged by D. B. Ward : by A. M. EDWARDS.

30. Circulation of Protoplasm (Cyclosis) in *Nitella* : by M. M. LE BRUN.

31. Young Codfish, one to three days old : by H. W. CALEF.

32. Transverse Section of the Leaf of the East India Rubber Tree, *Ficus elastica*, showing fibres, ducts, stomata, and cell tissue : by FREDERICK KATO.

33-36. Living and Pictorial Illustrations of Several of the Lower Forms of Animal and Vegetable Life : by STEPHEN HELM.

37. Pond Life : by A. D. BALEN.

38. Cinchonidine, shown by polarized light : by Miss M. V. WORSTELL.

39. Circulation of Protoplasm (Cyclosis) in *Chara* : by J. D. HYATT.

40. Ciliary Motion on the Gills of the Mussel : by J. D. HYATT.

41. Tongue of a Cricket : by W. D. MACDONALD.

42, 43. Pond Life : by H. C. WELLS.

44. The Curious Aquatic Insect, *Rheumatobates Rileyi* Bergroth, captured at Flatbush, L. I.; named by E. Bergroth, M.D., Tammerfors, Finland; and until recently the only reported specimen in the world : by J. L. ZABRISKIE.

45. Arranged Group of Diatoms, illuminated by parabola : by C. F. COX.

46. Crystals of Sugar, shown by polarized light : by C. F. COX.

47. Leaf of *Deutzia scabra*, showing stellate hairs : by W. E. DAMON.

48. Spines of *Echinus* : by H. G. PIFFARD.

49. Circulation of Blood in Tail of Tadpole : by F. W. DEVOE.

50. Circulation of Protoplasm in *Vallisneria spiralis* : by F. W. DEVOE.

51. File-tongue (*Odontophore*) of the New Jersey Conch, *Sycotypus canaliculatus*, with the shell : by SAMUEL LOCKWOOD.

52. File-tongue (*Odontophore*) of California Trochus, *Calliostoma canaliculatum*, with the shell : by SAMUEL LOCKWOOD.

53. File-tongue (*Odontophore*) of Patella, or Limpet Shell, *Acmaea testudinalis*, New England coast, with the shell : by SAMUEL LOCKWOOD.

54. Photomicrographic Apparatus : by F. D. SKEEL.

55-59. Star-fish and Sea-urchins, illustrated by living forms, microscopic specimens, and drawings : by G. W. KOSMAK.

60-66. Etchings of Steel Rails, showing Structure : by P. H. DUDLEY.

60. A .60% carbon Rail, with broad, shallow head. Dense structure.

61. A .45% carbon Rail, with deep head. Porous structure.

62. A good wearing Rail, made in 1863.

63. A rapid wearing Rail, made in 1880.

64. Nickel Armor Plate.

65. Specimens of Tests of Armor Plate, Ordnance, and Rail Steel.

66. Photographs of Drop Tests of a .60% Carbon Rail, etc.

67, 68. Sections of Silicified Wood, *Araucaria Briggsii*, from Arizona : by T. B. BRIGGS.

67. Transverse Section.

68. Radial Section.

69. Section of Wood, *Araucaria excelsa*, from Norfolk Island : by T. B. BRIGGS.

70. Platino-cyanide of Yttrium, shown by polarized light : by E. G. LOVE.

71. Seeds of *Orthocarpus purpurascens* : by E. G. LOVE.

72. Pollen of Mallow, *Malva rotundifolia* : by E. G. LOVE.

73. Foot of Spider : by E. G. LOVE.

74. Photomicrographs : by E. G. LOVE.

75. Pond Life : by W. C. KERR.

76. A Living Diatom, *Bacillaria paradoxa* : by T. CRAIG.

77. *Hydra viridis*: by J. C. THOMPSON.
78. Circulation in Frog's Foot: by J. C. THOMPSON.
79. Pond Life: by O. H. WILSON.
80. Circulation of Protoplasm in the Skin of the Onion: by M. DUPUY.
81. Colored Drawings of Microscopic Objects: by M. DUPUY.
- 82-86. Microphotographs, selected: by S. N. AYRES.
87. Fossil Vegetable Structure in Coal Shale: by GEO. E. ASHBY.
88. Section of Stalactitic Chalcedony, shown by polarized light: by J. W. FRECKELTON.
89. Desmids: by E. J. WRIGHT.
90. Quartz Inclusions in Mica, shown by polarized light: by A. H. EHRLMAN.
91. Microphotograph of Niagara Falls: by H. FINCKE.
92. California Gold Sand: by H. FINCKE.
93. Arranged Diatoms: by H. FINCKE.
94. Nitroprusside of Sodium, shown by polarized light: by H. FINCKE.
95. Section of Malacca Cane from Malay Peninsula: by A. WOODWARD.
96. Ash Block containing Living Termites, *Calotermes flavicollis*, taken at the Isthmus of Panama, August, 1890: by J. BEAUMONT.
97. Specimen of Termite Tree Nest, *Termes minimus* Beaumont, with alcoholic specimens of queen, soldiers, and workers: by J. BEAUMONT.
98. Cultivation, Staining, and Mounting of Bacteria: by P. H. LYON.
99. Circulation in the Tail of a Gold-fish: by W. H. MEAD.
100. Tooth of Fossil Fish in Coal: by THE SOCIETY.

MEETING OF APRIL 21ST, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Fourteen persons present.

Dr. Frank Abbott, Jr., was elected a Resident Member of the Society.

On motion the thanks of the Society were tendered Mr. Morris K. Jesup, President of the Board of Trustees, and the Officers of the American Museum of Natural History, for their kindness in granting the use of the Halls of the Museum, and for their generous assistance in the matter of the late Annual Exhibition of the Society.

OBJECTS EXHIBITED.

1. Gas carbon filaments, deposited on the edge of a burner:
by E. G. LOVE.
 2. Diatoms from the Bay of Bengal: by H. C. BENNETT.
 3. Section of Cementstein from Sendai, Japan: by H. C. BENNETT.
 4. Living diatoms: by C. S. SHULTZ.
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MEETING OF MAY 5TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Sixty persons present.

Dr. George M. Sternberg delivered the address announced on the programme, entitled "Bacteria." This address was most admirable for its comprehensiveness and its perspicuity, and was beautifully illustrated by a most remarkable series of lantern projections.

On motion the hearty thanks of the Society were tendered Dr. Sternberg.

MEETING OF MAY 19TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-four persons present.

Dr. Samuel Lockwood addressed the Society on "Some Phenomena in Exuviation by the Reptiles." This address was illustrated by specimens and objects under microscopes, as noted in the programme below, and is published in this volume of the JOURNAL, page 55.

OBJECTS EXHIBITED.

1. Bronze, life-size representations of Snake, Lizard, and Frog.

2. "Scarf" of Anaconda.
3. Skin of the Lizard, *Anolis principalis*, under a $\frac{1}{8}$ objective, showing "the windows."
4. Skin of the Horned Toad, *Phrynosoma cornuta*, under a $\frac{1}{8}$ objective, showing pigment grains.
Exhibits Nos. 1-4, inclusive, were by SAMUEL LOCKWOOD.
5. Photomicrograph, half-tone print, of scale of Podura, *Lepidocyrtis curvicolis*, $\times 3,000$: by H. G. PIFFARD.
6. Photomicrograph of pygidium of Flea, taken by Dr. Henri Van Heurck, who regards this object as a test, second in value only to the Podura scale: by H. G. PIFFARD.
7. Various Diatoms: by NOAH PALMER.

Some points on the changeability in color of the skin of the Chameleon, in Dr. Lockwood's address, were discussed by Messrs. J. D. Hyatt, L. Riederer, and W. J. Lloyd. Mr. Riederer suggested that the changeableness may be somewhat on the principle of "Newton's rings," since there are two films in the skin of the chameleon.

MEETING OF JUNE 2D, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-four persons present.

Dr. H. G. Piffard read a paper entitled "An Improvement in the Correction of Lenses for Photomicrography, Photography, and Photoastronomics." This paper was illustrated by many photomicrographs, as cited below.

OBJECTS EXHIBITED.

1. Watson's Van Heurck Stand: by H. G. PIFFARD.
2. *Navicula rhomboides*, under a William Wales $\frac{1}{10}$, made eighteen years ago: by H. G. PIFFARD.
3. The same; resolution of "beads," with parabola: by H. G. PIFFARD.
4. Podura scale: by H. G. PIFFARD.
5. Photomicrographs: blood of *Amphiuma*, *Echinus* spine, probe platte, histological section, Podura scale, *Amphipleura pellucida*, *Limulus*, copy of a painting, street scene, interior view: by H. G. PIFFARD.

6. *Amphipleura pellucida* : by HENRY C. BENNETT.
7. Probe platte by Möller : by HENRY C. BENNETT.
8. Photomicrographs : *Amphipleura* \times 1,500, *Pleurosigma angulatum* \times 6,000, section of human eye : by F. D. SKEEL.
9. *Frustula saxonica*, $\frac{1}{10}$ homogeneous immersion lens and vertical illuminator : by CHARLES S. SHULTZ.

MEETING OF JUNE 16TH, 1893.

The Vice-President, Dr. E. G. Love, in the chair.

Dr. F. D. Skeel was elected Secretary *pro tem*.

Surgeon-General George M. Sternberg, U. S. A., was elected an Honorary Member of the Society.

Dr. E. G. Love, chairman of the Committee on Annual Exhibition, reported for the Committee, and the Committee was discharged with thanks.

OBJECTS EXHIBITED.

1. According to previous appointment, the entire collection of "Jackson Slides," recently purchased by the Society, were exhibited in succession.

2. Photomicrographs of *Triceratium favus* \times 1,500, and of *Pleurosigma angulatum* \times 750 and 6,000 : by FRANK D. SKEEL.

The Society adjourned to the first Friday of October, 1893.

PUBLICATIONS RECEIVED.

American Monthly Microscopical Journal: Vol. XIV., Nos. 2—9 (February—September, 1893).

The Microscope: Vol. I., Nos. 2—10 (February—October, 1893).

San Francisco Microscopical Society: Proceedings (April 9—March 1, 1893); Transactions, Part I. (1893).

Bulletin of the Torrey Botanical Club: Vol. XX., Nos. 3—10 (March—October, 1893).

Insect Life: Vol. V., Nos. 4, 5 (April, July, 1893).

Psyche: Vol. VI., Nos. 204—211 (April—November, 1893).

The Observer: Vol. IV., Nos. 1—10 (January—October, 1893).

Proceedings of the Natural Science Association of Staten Island: Index of Vol. II. (November 10, 1888—October 10, 1891); Meetings (March 18—October 14, 1893).

Anthony's Photographic Bulletin: Vol. XXIV., Nos. 5—21 (March 11—November 11, 1893).

School of Mines Quarterly: Vol. XIV., Nos. 2—4 (January—July, 1893).

American Museum of Natural History: Annual Report (1892).

New York Academy of Sciences: Index of Vol. XI. (1892); Transactions, Vol. XII. (1892, 1893).

Proceedings of the American Academy of Arts and Sciences: Vol. XXVII. (1892).

Proceedings of the Boston Society of Natural History: Vol. XXVI., Part I. (November, 1892—May, 1893).

Proceedings of the Academy of Natural Sciences of Philadelphia: 1893, Parts I. and II.

Bulletin of the Museum of Comparative Zoölogy at Harvard College: Vol. XXIV., Nos. 6, 7—Vol. XXV., No. 1 (July—September, 1893).

Journal of the Franklin Institute: Vol. CXXXV., No. 807—Vol. CXXXVI., No. 815 (March—November, 1893).

Transactions of the Massachusetts Horticultural Society: Part II., 1892; Part I., 1893.

Journal of the Elisha Mitchell Scientific Society: Vol. IX., Part II. (1892).

Transactions of the Connecticut Academy of Arts and Sciences: Vol. VIII., Part II.; Vol. IX., Part I. (1893).

Report of the Missouri Botanical Garden (1893).

United States Geological Survey: Eleventh Annual Report, Parts I. and II. (1889—90).

Proceedings of the Rochester Academy of Science: Vol. II., No. 2 (1893).

Bulletin of the Essex Institute: Vol. XXIV., No. 7—Vol. XXV., Nos. 1—6 (July, 1892—June, 1893).

Journal of the Cincinnati Society of Natural History: Vol. XV., No. 3—Vol. XVI., No. 3 (October, 1892—October, 1893).

Cornell University Agricultural Experiment Station, Bulletins: Nos. 50—57 (March—September, 1893).

Bulletin of the Michigan Agricultural Experiment Station: Nos. 90—99 (February—July, 1893).

Bulletin of the Iowa Agricultural Experiment Station: Nos. 20, 21 (1893).

Bulletin of the Alabama Agricultural Experiment Station: Nos. 41—47 (December, 1892—July, 1893).

Bulletin of the Texas Agricultural Experiment Station: No. 26 (March, 1893).

Bulletin of the Division of Entomology, U. S. Department of Agriculture: Nos. 29, 30 (1893).

Colorado Scientific Society: Six pamphlets (1893).

Journal of the Royal Microscopical Society: Parts II.—V. (1893).

International Journal of Microscopy and Natural Science: Vol. III., Nos. 18—20 (April—October, 1893).

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ON UNIFORMLY STAINED COVER-PREPARATIONS
OF MICRO-ORGANISMS, FREE FROM DISTORTION.

BY ALEXIS A. JULIEN, PH.D.

(Read November 3d, 1893.)

The morphological differences between the kinds of bacteria will be probably found as distinct as in all other micro-organisms. Recent investigations have begun to emphasize their specific peculiarities in internal structure and enclosures and in their outer organs of motion, and the value of these in diagnosis of species. A common impression to the contrary, long and often expressed among bacteriologists, is certainly based, I think, on unsatisfactory results which have been naturally derived from some present easy methods of preparation of material, the use of lenses of easy-working distance but narrow aperture, and easy but ineffective methods of manipulation. The higher needs of modern bacteriology surely call for methods of patient and painstaking treatment analogous to those long used on histological preparations. There are serious objections to the process, now in almost universal use, for the mounting of pure growths of bacteria and micro-organisms, and enjoined in most text books¹—the smearing of covers with droplets of the growth under the edge of a slide drawn across the surface, or by rubbing the droplet

¹ E. M. Crookshank, "Manual of Bacteriology," 3d Ed. (1890), 65. G. M. Sternberg, "Manual of Bacteriology" (1892), 26, 27.

between two covers, afterward drawn apart ; the completion of the drying of the film on the cover by passing it to and fro through a flame ; and the staining in simple solutions of anilin colors in water, anilin-water, or alcohol. No worker should any longer waste his time and labor on such a process, with its known miserable results in imperfect mounts and the unsatisfactory conclusions they must yield.

1. The material is spread irregularly. On account of its ordinary glutinous character and excessive richness in forms, the film on most bacteria mounts is either rendered too dense, crowded, and opaque, or, at the other extreme, is represented by a few scanty wisps or streaks, for which a tedious search must be made all over the cover.

2. The true structure and grouping of the bacteria are disturbed or destroyed. In the rough process of smearing, the delicate attachment of the elements of bacterial filaments and of groups of cocci, often loosely aggregated, is rudely broken up. In place of bacterial chains, the student often obtains a film, partly or wholly consisting of desiccated and widely scattered bacilli ; in place of streptococci, groups of four, grape-like bunches and cubical packets, he finds solitary cocci and perhaps a few lonely diplococci ; and, very likely, his original spirilla and even vibrios have been nearly all rent apart into isolated curved bacilli ; there is now a question whether some of the so-called spirochæte may not be but the paddles torn away from the bodies of roughly handled hæmatozoa.

As the discrimination of bacterial species, still very difficult, depends partly, often largely, on recognition of original forms and grouping, the present destructive and clumsy process of smearing has often long delayed the detection of important facts (*e.g.*, the spirillum form of the organism connected with Asiatic cholera) and ought to be entirely rejected. For these reasons several writers have recently recommended the previous dilution of the original bacterial growth with sterilized water upon the cover, or before its application to the cover. In fact, we have had one truthful process, in preservation of bacterial forms, that of cover-impressions from the surface of solid and liquid media ; but these have been of limited and often difficult application.

3. Further distortions of form occur during the processes of

drying of the film. The elements of groups are falsely disturbed, even with those lucky organisms which have escaped injury during the preceding rough treatment. These may be due to contraction during drying, and it may affect even forms and groups whose shapes allow them to be pressed down upon a plane surface without distortion, such as rods, cocci, chains, and merismopedia. The bacteriologist is familiar with the faulted lines and short offsets which signify irregular shrinking during overhasty drying of these delicate watery organisms, and with ghostly lines and spots showing where they have drawn aside or often split entirely away from the cover. But with those forms which must obviously become distorted when flattened upon a plane surface, such as many vibrios and all spirilla, spirochæte, staphylococcus bunches, and sarcina packets, any process of drying upon covers must be objectionable on account of this distortion. Still further, during the drying of ciliated forms in active motion, even at the natural temperature of the laboratory, a serious cause of deformation arises from the writhing toward the end of the drying, especially in forms which become cemented at one end to the cover, while the remainder continues twisting and wriggling into strange, often fractured shapes. These contortions and dislocations can be actually watched during the struggles of the entrapped micro-organisms, and are abundantly displayed on any film of dried spiral bacteria and in numerous published photomicrographs; spirilla are shown twisted into a curve, spirochæte actually bent at right angles, etc. A recent example of such distortion is shown in the photomicrograph of *Sp. volutans* by Dr. R. L. Maddox, accompanying his interesting paper in the *Journal* of the Royal Microscopical Society for December, 1893; he had already shown the true form in his previous paper in the *International Journal of Microscopy and Natural Science*, iii. (1893), page 233.

The needed precautions, in my opinion, are, first, that all micro-organisms, including bacteria, should be suddenly killed and fixed before evaporation of the film or any other process of mounting, especially those of active movement; secondly, that such evaporation should be carried on very slowly and at a low temperature, especially with curved and thick organisms. One purpose of the evaporation, especially the later heating in or over

a flame, has been the coagulation of albuminoids in the liquid of the drop, to prevent general coloration of the field during staining. But this is the common cause of resistance to staining by delicate inner details and the cilia, while it can be well effected by immersion in a proper fixative. A second purpose of this excessive drying has been the supposed necessity to insure adherence of the film to the cover. But I have found that when a film is well dried at low temperature, as explained beyond, no peeling away or loss afterward occurs.

4. The staining is irregular and unsatisfactory. In most bacteria mounts, as met everywhere on exhibition, these forms are greatly overstained and look all alike, presenting mere silhouettes of the contours, with few or no traces of inner structure and with cilia entirely invisible. For a long time it has seemed to be the acme of effort to render these microbes visible at all. This has been followed by special efforts to effect satisfactory staining of spores or of cilia, in separate preparations. Nor is it strange that many bacteriologists have concluded that these silhouettes show the prevalence of such a sameness of form among the kinds of bacteria that the main dependence, for discrimination, must be placed on other characteristics of a physiological nature, modes of growth on different media, etc.

But these opaque caricatures of the bacteria are as unworthy of modern science and as unnecessary as similar misrepresentations of the infusoria or other micro-organisms would be considered. The improvement of modern lenses of wide aperture, and increasing facility in their manipulation, are gradually leading as well to more successful approach toward the preparation of an ideal bacteria mount. This should of course present the groups or chains dispersed over the whole cover, with natural arrangement undistorted and unbroken, with normal mode of interconnection, and with constituent rods or cocci just sufficiently stained to display both inner structure and external organs. To this end the anilin stains are commonly misused, being greedily and excessively absorbed by the plasm within the cells, while cellulose, callose, etc., remain unaffected. With a dried bacteria film, therefore, the preliminary use of some mordant is indispensable for staining, to restore the absorbence in all parts of the organism.

However, it is probable that the drying and heating of the bac-

teria film, perhaps to any degree, must cause such contraction of the sensitive plasm within the cells and of that connected with the cilia as to involve just this known resistance to coloration. In several recent investigations there has been a return to simple processes by which, without drying or heating, the living bacteria have been successfully stained throughout, including the cilia ; for example, that of N. Sjöbring,¹ who, in studies of their structure and nuclei, used nitric acid as fixative, stained with carbol-methylen-blue or carbol-magenta-red, decolorized with nitric acid, and examined in glycerin and water ; that of Straus,² who merely added diluted Ziehl's solution to a loopful of bouillon culture of several kinds of spirilla ; that of Klein,³ who used, on the living spirillum of Asiatic cholera, a mixture of equal parts of absolute alcohol and a solution of gentian-violet in anilin water, during five to ten minutes ; and that of R. L. Maddox,⁴ who used saturated solution of tannic acid as fixative, and then added a saturated solution of iron sulphate, containing about two per cent of citric acid, for the staining of spirilla. Not only, therefore, is it certain that the process of drying and overheating bacteria on thin covers long delayed the discovery of cilia and other details and is yet impeding their investigation, but it is probably responsible for some of the varying conclusions of modern workers concerning distribution of chromatin, septa, nuclei, spores, and cilia through artificial and false structures developed by contraction.

To recapitulate, the new steps suggested by these considerations, when it is thought desirable to prepare a dried bacteria film, are as follows : preliminary dilution of a droplet of the bacterial growth in sterilized distilled water ; killing and fixation of the bacteria, in a drop upon a thin cover, by addition of suitable fixative ; slow evaporation at a low temperature ; and immersion in a mordant before staining.

As to the selection of fixative, I have tried weak aqueous solutions of the following reagents, in succession or in comparative series, during the recent preparation of two hundred and thirty mounts of several species of ciliated bacteria, spirilla of *Beggiatoa*, spirilla undula, etc. As the fixative cannot be removed from

¹ *Centralbl. f. Bakt. u. Par.*, xi. (1892), 65.

³ *Idem*, xiv. (1893), 618.

² *Idem*, xiv. (1893), 257.

⁴ *Jour. Roy. Mic. Soc.* (1893), 718.

such minute bodies as the bacteria, before evaporation, but must be evaporated with the drop on the cover, the results of such concentration of each fixative must be considered in determining its value. The following were found to be efficient in killing instantaneously and as fixatives, but were all objectionable in that their intermixture with the bacteria in the form of crystalline tufts or flakes, by concentration during the evaporation of the drop, seemed to lessen the adherence of the film, which separated in spots during subsequent processes of the preparation: viz., sodium chloride, iron sulphate, iodine in solution of potassium iodide, chloral hydrate, quinine sulphate, morphia sulphate, hydroxylamin, Loeffler's mordant, and fuchsin solution. Of these sodium chloride was the simplest, and often quite efficient. Osmic acid, picric acid, ether, and chloroform were more satisfactory, but especially absolute alcohol, though this last reagent was objectionable on account of the violent currents produced on its addition in a droplet. The best results were obtained with hot water, tannin, chromic acid (in water solution, diluted until colorless by daylight), and hydrogen peroxide.

As to the staining process, that of Loeffler, with two solutions, mordant and colorant, though specially devised for the staining of cilia, appears well adapted for the staining of the entire bacterium. However, in place of the unstable salt, iron sulphate, recommended in his formula, it seems better to use, as suggested by L. Luksch,¹ a cold saturated solution of ferric acetate, with addition of a few drops of acetic acid. The further addition to the mordant—on which Loeffler lays so much stress—of a few drops of solution of sodium hydrate or of hydrochloric acid, according to the alkaline or acid reactions of the natural products of growth of the bacterium which is to be stained, has been found unnecessary by M. Nicolle and V. Morax.² With this my own experience coincides; no actual change of reaction is produced in the mordant, nor any improvement in the results; the variable and uncertain staining of cilia, often observed, seems to be dependent on quite other conditions, probably connected with the anterior drying of the film. The two solutions as simplified

¹ *Centralbl. f. Bakt. u. Par.*, xii. (1892), 430.

² *Ann. de l'Inst. Past.*, vii. (1893), 554.

by Loeffler in his second method,¹ and modified as already suggested, are now made in the laboratory of Micro-Biology at Columbia College as follows :

Mordant.—To 10 c.c. of solution of tannin (20 per cent in water) add commercial solution of iron acetate, drop by drop (about 5 c.c.), until a violet-black is produced without precipitate. Then add 5 to 10 drops of acetic acid and 4 c.c. of solution of carbolic acid (12 per cent in water), and filter. With ordinary protection from the air, the solution is stable for a long time.

Loeffler also adds 1 c.c. of fuchsin solution to the mordant, and so also Nicolle and Morax, with the special purpose to insure staining of the cilia. As my own object is the more general one of effecting a uniform and harmonious coloration of the entire bacterium, I find the results under better control by confining the anilin color to the colorant proper.

Colorant.—To 100 c.c. of anilin water add solution of sodium hydrate (1 per cent in water), drop by drop (about 5 c.c.), until a neutral reaction is obtained with test papers. Then add $\frac{1}{2}$ gramme of fuchsin and shake until solution; but filter every time just before using. From time to time, as the solution loses color by decomposition, add a little more fuchsin and shake up before filtering.

In the original process, with exclusive object of staining cilia, Loeffler uses 4 grammes of fuchsin, and Nicolle and Morax, Ziehl's fuchsin—both solutions being saturated with stain and opaque. On films prepared by my method, fixed and dried with little or no heat, the results appear more satisfactory with an alkaline solution like that of Loeffler, though containing but one-eighth of the amount of stain he prescribes, brightly colored but transparent.

A supposed improvement of Loeffler's process has been advanced by A. P. Brown,² who substitutes as mordant a cold alcohol solution of tannin and anilin oil, in which the dried bacteria film is to be immersed for two to five hours or over night. This method also I have tried for about a month, and, although it often yields excellent results, it has appeared to be less certain and uniform than the hot mordant recommended by Loeffler.

¹ Jour. de Micrographie, xv. (1891), 269.

² The Observer, iii. (1892), 293, and Jour. Roy. Mic. Soc. (1893), 268.

The latter has also the great advantage of speed, as the mordanting is effected in less than a minute.

Both Loeffler, and Nicolle and Morax, have advised the repetition of application of the mordant two or three times in some cases. In this I have found no apparent gain; the entire action of the hot mordant on these minute bodies seems to be completed during a single brief immersion.

In all these methods much loss of time would be incurred from treating the covers, as advised, one by one, with drops of mordant and of colorant over a flame. I have elsewhere¹ already indicated the far easier, quicker, and more convenient staining carried on in a wire spring holding a dozen or more covers, with film downward, in the hot mordant or hot stain in a small flask. The dried coloring and overstaining may be thus obviated, for which Loeffler prescribes washing in absolute alcohol.

We may now consider the application of these methods to various micro-organisms, availing ourselves of useful suggestions from the writers referred to.

Preparations of Bacteria.—In making mounts from pure cultures the following process is now used in our laboratory. After drying of the film it ordinarily requires only ten to fifteen minutes for the staining and complete mounting of the preparation. In three or four drops of sterilized water, in a flamed watchglass, stir very gently a particle or droplet of the pure bacteria culture (taken preferably from the surface of a growth on potato or agar) on a platinum wire loop or öse until a slight cloudiness is produced; then take it all up at once within a sterilized droptube with rubber bulb. Lay a series of thoroughly cleaned thin covers (treated in Seiler's solution and washed in distilled water and pure alcohol) on the bottom of a shallow two-inch Petri dish. Apply to each, and spread very gently, a drop of the diluted culture, and immediately add to the centre of the drop a droplet of the selected fixative (say, tannic acid or chromic acid solution). If a sparser distribution of the bacteria is desired, allow the drop to settle a few minutes, take up and incline each cover, and remove excess from lower edge. Allow to dry, with protection from dust, at the natural temperature of the room, or

¹ "Suggestions in Microscopical Technique," this JOURNAL, ix. (1893), 26.

over concentrated sulphuric acid within a desiccator, or, still better, in vacuo over sulphuric acid, under an air-pump.

When thoroughly dry, insert all the covers in the brass wire coil, with film surfaces all directed toward its lower end, and with arranged and noted succession for identification, if different kinds of bacteria are included in the series. With some species it appears desirable to hold the coil a few seconds in a current of warm air to complete the drying.

Dip the coil for a moment in sterilized water, to dissolve away excess of fixative, remove the water drops by touching absorbent paper, and again dry the covers.

Hang the coil for one-half to one minute in the flask of mordant, heated nearly to boiling. Remove the coil and take up excess of mordant by touching absorbent paper; wash by swinging gently, for about five seconds, in a vessel of distilled water, then in solution of acetic acid (20 per cent), again in water, and remove water drops by touching absorbent paper.

Without drying, hang the coil in the flask of hot colorant for five to sixty seconds, according to depth of staining desired and the readiness of absorbence of the species, determined by trial. Remove the coil, take up excess of stain by touching absorbent paper, and wash as before in another vessel of distilled water.

Remove the covers from the coil, and lay, film downward, on a soft filter paper. Dry by pressing gently under another filter. Clean the upper face of each cover by rubbing with corner of rag moistened with alcohol, keeping the cover stationary to avoid rubbing away the underlying film. Lay upon a glass slide, remove to stage of microscope, and examine and select the covers preferable for mounting.

Mount in hardened balsam, or in a saturated solution of potassium acetate within a very shallow spun cell of balsam-paraffin, King's cement, or Hollis glue. In cases, delicate details of structure may be best shown by mounting in air—*e.g.*, over a filmy ring of paraffin.

The fugitive character of staining effected by anilin colors has recently led E. Van Ermengem to devise the following process¹ of staining the cilia of bacteria, founded on the reduction of silver from a solution of its nitrate.

¹ Ann. de Micrographie, v. (1893), 394.

The well-dried bacteria films are immersed half an hour (or, if need be, five minutes at 60° C.) in the

Fixing Bath.

Osmic acid (2 per-cent solution)	1 part.
Tannin (10- to 25-per-cent solution).....	2 parts.

They are then washed with utmost care in water and in alcohol, and placed a few seconds in the

Sensitizing Bath.

Silver nitrate, a very weak solution (0.5 to 0.25 per cent).

Without washing, they are next subjected to the action of the

Reducing Bath.

Gallic acid.....	5 parts.
Tannin.....	3 “
Melted sodium acetate.....	10 “
Distilled water.....	350 “

After a few moments they are returned to the silver bath, removed when the bath begins to blacken, washed thoroughly, dried, and mounted in balsam.

I have made trial, with some success, of this promising method, in reference to the more general object of the present paper. So far I find an objectionable tendency to blackening and over-staining of the whole preparation, which I think may be obviated by reducing the strength of the baths.

The successful results already obtained in direct staining of living bacteria by simple processes, like those of Sjöbring, Straus, Klein, and Maddox, warrant the prophecy that some such process, with or without application of mordant, as tested on each kind, will yet come into general use when the utmost perfection is desired in a preparation. In other cases such staining of living bacteria may well precede their drying on covers in the ordinary way, when the containing liquid is sufficiently free from substances inclined to absorb the stain.

Preparations of Spirilla.—In regard to spirochæte, spirillum, and vibrio forms, the preliminary process of killing with a fixative, before evaporation of the film, was found to have materially

reduced the number of distorted spirals, apparently all that would have been produced by writhing movements of organisms partially adhering to the cover. Only those remained that were inseparably connected with the process of flattening down spiral forms upon a plane surface. To eliminate this last source of deformation the following process has been devised, which requires some care and patient manipulation, but yields the spirilla in perfect preservation. There is, of course, greater difficulty of studying a spiral under a high magnifying power, and a troublesome tendency of these spiral forms to intertwist in bunches during concentration.

Put a sufficient quantity, say 20 c.c., of the liquid containing the living bacteria in a conical sherry glass or in a urinary deposit tube. Add a little fixative, say 5 c.c. of tannic acid or chromic acid solution, mix by shaking gently, and allow to settle for at least half an hour. Draw off the supernatant liquid, with utmost care not to disturb the light invisible deposit, and wash by a change of sterilized water, allowing to settle as before. Draw off the liquid and transfer the deposit to a number of slides with very shallow cells. Add to each a drop of cold colorant, remove excess by slips of absorbent paper, and wash by changes of sterilized water, removing each by absorbent paper. Then add saturated solution of potassium acetate, cover, and seal.

Preparations of Amœboid Organisms.—The difficulty of preparing permanent mounts of amœbæ, foraminifera, etc., is shown by the rarity of such preparations in all collections and exhibitions. The long-accepted but unfounded conviction as to the constitution of such forms of but slightly differentiated and therefore unstable protoplasm has probably led to discouragement of much effort in this direction.

Certes has advised the following process¹ for preparation of mounts of amœbæ. To 30 c.c. of the water containing the living amœbæ about 1 c.c. of osmic acid solution (1 per cent) is added. After settling a few hours, the deposit is washed, concentrated, stained, and mounted in distilled water containing a trace of osmic acid.

I have not succeeded by this method, partly perhaps on account of the loss of amœbæ in the confusedly heaped-up mass of asso-

¹ R. Gérard, *Traité pratique de Micrographie* (1887), 333.

ciated algæ and infusorians, the bending and distortion of the flexible pseudopods, and the obscuring effect of the common black deposit of reduced osmic oxide. My discovery, on examination of preparations of bacteria by the method already explained, that accidentally I had also successfully mounted some associated amœboid forms, has resulted in the following process. It has so far been found satisfactory with *Amœba radiosa*, small forms of *A. princeps*, *Arcella acuminata*, *Actinophrys sol*, and some amœboid forms. From present want of proper material I have been unable to determine what modifications may be needed with the larger forms of amœbæ, and of other rhizopods with bulky gelatinous material, to prevent distortion by contraction during the drying of the film.

The thoroughly cleaned thin covers are laid on the bottom of a small Petri dish or similar shallow tray; to each a large drop of the water containing the living organisms is added, and then set aside in a "moist chamber," in a quiet, dark, but warm place, for fifteen to sixty minutes. The object is to allow sufficient time for the rhizopods to recover from alarm and to creep about, projecting their pseudopods in a natural way, and yet to prevent any evaporation of the drops. A simple method is to fill a common finger bowl half full of warm water (at 30° to 35° C.), to set the shallow dish or tray floating upon the surface of the water, and to cover the whole from the light with a large wet towel folded several times. The vessel is then gently uncovered, without jar, and to each drop a droplet of fixative is added quickly by touching from a drop-tube, but not by dropping, as that would tend to cause tremor in the drop. As fixatives, hydrogen peroxide, absolute alcohol, chromic acid solution, and, perhaps best of all, osmic acid solution (1 per cent), were used. The tray is then removed from the "moist chamber," the drops are allowed to evaporate, as in the process for preparations of bacteria, and the films treated as before explained.

Also, to a drop of water containing rhizopods under observation, on the stage of a microscope (an inverted stand is preferable), under a half-inch objective, the droplet of fixative may be directly applied at the proper moment of the projection of the pseudopods, and the evaporation, etc., then carried on as already described.

Preparations of Infusorians.—Excellent methods have been devised for preparations of these organisms by Certes, K \ddot{u} nstler,¹ Fabre-Domergne,² and others. My method, by evaporation, is perhaps only applicable to the smaller forms. With the larger, hitherto, in my experiments, the dried organisms become injured by bursting and outflow, or by irregular contraction, the contour of the sac even parting often from the cilia. With smaller forms the process specified for bacteria may be followed, with use of the special fixative found by trial best suited to each species—*e.g.*, concentrated solution of osmic acid (K \ddot{u} nstler), boiling solution of tannic acid, 3 per cent (C. O. Sonntag),³ equal parts of osmic acid solution (1 per cent) and acetic acid (20 per cent), Kleinenberg's solution, alcohol, chromic acid, picric acid, etc. The dried minute infusorians, like the smaller rhizopods thus prepared, seem as well adapted for study as the bacteria in a dried film, as they display the cilia, sac, vacuoles, nuclei, enclosed food particles, etc., in a satisfactory state of preservation, with no visible distortion.

In place of drying the larger infusorians, the following method has been found useful. They are first narcotized in the drop of water, under observation with a low power, after the method of E. A. Schultze,⁴ by addition of a neutralized solution of hydroxylamin hydrochloride (0.25 to 1 per cent), or by Rousset's method⁵ for rotifers, by addition of a weak solution of cocain hydrochloride. At the moment the cilia cease to move the organisms are suddenly killed, after Schultze's method, by adding a drop of alcohol, picric acid, or acetic acid; or, after Rousset's method, by a drop of osmic acid solution (1 per cent), or by a drop of Flemming's mixture (15 parts of chromic acid, 1-per-cent solution; 4 parts of osmic acid, 2-per-cent solution; and 1 part of glacial acetic acid). The organisms are then washed and stained, as described in preparations of spirilla. The use of Loeffler's mordant on the infusorians is found of the highest advantage, as the cilia become readily absorbent of stain to any depth of coloration desired. A serious difficulty is found in the

¹ Jour. de Micrographie, x. (1885), 59.

² "Notes techniques sur l'étude des Protozoaires," Ann. de Micrographie, ii. (1889), 545.

³ Internat. Jour. of Mic. and Nat. Sci., iii. (1893), 306.

⁴ This JOURNAL, viii. (1892), 28.

⁵ Jour. Quek. Micr. Club, 2, v. (1893), 205.

greedy absorbence of the anilin dye by the protoplasmic sarcode ; but the overcoloration may be controlled by proper dilution of the stain. The infusorians are then mounted in balsam, Wickersheimer's fluid, or other preservative, in the usual way.

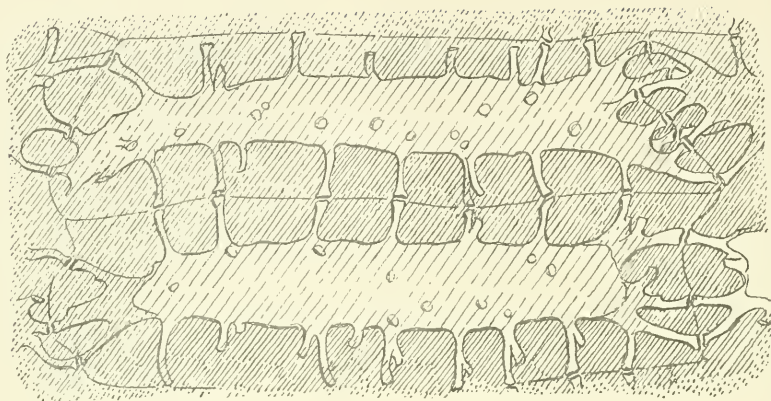
NOTE ON THE STRUCTURE OF THE ENDOSPERM
OF PHYTELEPHAS MACROCARPA RUIZ AND
PAVON, AND OF SMILACINA RACEMOSA
DESF.

BY J. L. ZABRISKIE.

(Presented December 15th, 1893.)

1. *Phytelephas macrocarpa*.—The seed of this plant, popularly known as the ivory nut, is an irregular ovate body about one and one-half inches in diameter by two inches in length. When it is cut through the middle transversely and longitudinally the endosperm discloses a "grain," easily seen with a hand lens, resembling in miniature the "grain" of the wood of an exogenous tree. The transverse section shows concentric circles sweeping around the longitudinal axis of the nut. The longitudinal section, through the middle portion of the nut excluding the poles, shows minute longitudinal bands nearly parallel with the axis. Close inspection shows why the poles must be excluded in referring to the bands as parallel with the axis. Rings and bands are found to conform quite accurately with the dark outer surface of the nut, so that when the poles are approached the bands sweep around the latter. It is as if the entire substance of the endosperm were composed of tenuous films or shells of "vegetable ivory," these shells conforming to the outer surface, closely fitting one within the other, and therefore gradually decreasing in size as they approach the axis.

The "grain" is caused by a remarkably uniform arrangement of similar, lengthened cells composing the entire endosperm. But the arrangement is diametrically opposite that which causes the "grain" in the tree. In the tree the cells of the fibre generally overlap each other, and all lie parallel with the axis, and of course parallel with the bark. And a ring or band is caused by the assembling of some of these cells, which are comparatively small.



1



2



3

PHYTELEPHAS AND SMILACINA.

in diameter, nearly consolidated by internal deposit, giving a darker hue and firmer texture to that portion of the structure and marking the cessation of the periodical growth of the organism; and so standing strongly contrasted with the immediately superimposed layer of thin-walled, larger cells which mark the periodically resumed activity of growth. In the ivory nut the cells are also somewhat lengthened, but, instead of lying parallel with the axis, they radiate from the axis, and all extend outward toward the dark outer surface and normal to its curve. The cells do not usually overlap each other, but with remarkable uniformity they lie side by side, and meet each other end to end. And the appearance of rings and bands is caused by dense clusters of tubules at the ends of these cells, the members of one cluster accurately meeting the members of another cluster from the ends of adjoining cells, the extremities of the approaching tubules, however, always being separated from each other by the middle lamella between two adjoining cells. These clusters are so dense and are so regularly arranged, on account of the usually regular position of the cells side by side, as well as end to end, that, by contrast with the portion of the cell intermediate between the ends—which intermediate portion, however, is also well furnished with tubules—the transverse section shows attenuated but unbroken, darkened circles sweeping around the axis.

Description of Plate 38.

FIG. 1.—Longitudinal section of two entire cells of the endosperm of *Phytelephas*, with four extremities of adjoining cells, meeting end to end. The cells are split longitudinally and cleared of cell contents. The darker shaded portions represent the upper surface of the section, showing the thickness of the cell walls. The lighter portions represent the semi-cylindrical cavity of the cell, like a minute trough, and also many of the tubules, which lie near the upper surface of the section and pass outwardly to the lamella or boundary of each cell. The small circles represent the openings of such tubules as are passing downward at various angles through the remaining thickness of the section. Many of the tubules at the ends of the cells are cut off at various lengths by the plane of the section.

FIG. 2.—Transverse section of a number of cells of the endosperm of *Phytelephas*, cleared of cell contents and showing the polygonal outlines. The plane of the section passes through the clusters of tubules at one end of the cells. The shaded portions represent the thickened cell walls, and the clear spaces the contracted lumen of this region of the cells.

FIG. 3.—Section of the endosperm of *Smilacina*, with its irregularly globular or ellipsoidal cells, cleared of cell contents. The darkest shaded portions represent those portions of the cell walls which rise directly upward to the upper surface of the section, and which, therefore, exhibit at best advantage the thickening of the cell walls and the abundance of tubules.

The three sketches are all of the same magnification—250 diameters.

Of course in multitudes of instances the end of one cell must meet the ends of two or more cells, to allow for the interposition of radii, as the view advances from axis to periphery—from one ring or film to the next outlying ring or film; but these instances are rare compared with the abounding number of regularly disposed cells in any one section when magnified.

These cells will average about .004 of an inch in diameter by .014 of an inch in length. The cell walls are so thickened by internal deposit that frequently the lumen, or cavity, is left of a diameter of only about one-third of the entire diameter of the cell. It is this deposit which causes the bone-like density of this remarkable vegetable product. The tubules, resulting from the avoidance of this deposit at certain points, are frequently curved and branched, and the clusters of these tubules at the ends of the cells are especially branched and tortuous, as they meet the members of similar clusters not only from the cell which lies directly in advance, but also from those which lie surrounding its polygonal periphery. It is not easy to count them, but the tubules of the cluster at one end of one cell undoubtedly often reach the number of twenty or more.

2. *Smilacina racemosa*.—This plant, of the lily family, and one of the common woodland herbs of our region, reaches a height of one to three feet, with a slender, simple stem, well furnished with oval leaves, and bears small white flowers in a terminal racemose panicle. The berries are pale red, speckled with purple, containing one or two seeds.

A section of these seeds discloses a very homogeneous but confused mass of irregularly globular or ellipsoidal cells, about .003 by .005 of an inch in dimensions, with greatly thickened cell walls, abundantly furnished with tubules, which latter are of large diameter compared with their length. The deposit averages not quite one-half of the thickness of that found in the ivory nut, but it is sufficient to make a near approach to the density of "vegetable ivory." The endosperm of this seed of *Smilacina* is probably the hardest of any recorded instance among the indigenous plants of our region. The seed is so hard that it can be easily driven with one blow of a hammer, and without fracture, flush into the substance of pine wood.

PROCEEDINGS.

MEETING OF OCTOBER 6TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-one persons present.

The Recording Secretary read a communication from Prof. W. Goold Levison, requesting the appointment of a committee by this Society to meet with committees of allied societies for the purpose of conference on the adoption of a uniform size for boxes, cases, and cabinets for the display and preservation of microscopical and mineralogical specimens.

Mr. James Walker was appointed as such committee.

OBJECTS EXHIBITED.

1. Capsules of Canada balsam, *in situ*, in the bark of *Abies balsamea* Miller: by ALFRED M. MAYER.

2. *Acineta tuberosa*.

3. *Bacillaria paradoxa*.

4. *Megalotrocha albo-flavicans*.

5. *Octocella libertas*.

6. *Urnatella walkerii*.

7. *Cordylophora coronata*.

8. The form, No. 1, of Plate 29 (see JOURNAL, viii., 43).

Exhibits Nos. 2-8 from the water of the Morris and Essex Canal, New Jersey, and all by STEPHEN HELM.

9. *Melicerta ringens*, living, and in the act of building its tube: by JAMES WALKER.

10. *Plumatella* sp.: by JAMES WALKER.

11. *Conochilus volvox*: by JAMES WALKER.

12. Pollen of Mallow: by HENRY C. BENNETT.

13. Photomicrograph of statoblasts of *Lophopus crystallinus*: by E. G. LOVE.

14. Mexican "Jumping Beans," *Sebastiania palmeri* Rose ("Insect Life," iii., 431), or *S. pavoniana* Müll. Arg. (Bull. Torr. Club, xx., 25), showing active motion: by F. D. SKEEL.

Mr. Helm remarked that specimens of his exhibit No. 7 had been very scarce in the canal during the present year. They had multiplied in one of his tanks during that time, but, had

suddenly died. On the 4th of this month a few specimens were found in the same tank. Also, the exhibit No. 7 showed a peculiarity of this form "No. 1"—twice the usual length, having twice as many processes, with small processes interspersed among the larger ones.

Mr. Walker said that he took his exhibits Nos. 9, 10, and 11 at Glendale, Long Island; and also that he had taken *Bacillaria paradoxa* in abundance in an undoubted fresh-water pool of the tunnel of the Northern Railroad of New Jersey, near Fairview.

Mr. F. W. Leggett stated that he had kept sea water pure in an aquarium for two years.

Mr. William E. Damon stated that he had kept sea water pure in an aquarium, without changing, for fifteen years, by means of floating specimens of *Ulva*.

Prof. Alfred M. Mayer donated specimens of the bark of *Abies balsamea* with capsules of balsam for distribution.

MEETING OF OCTOBER 20TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Fourteen persons present.

Dr. F. D. Skeel having offered to temporarily store at his residence the exchanges of the Society now being received, and for which there was no shelving now provided at the rooms of the Society, it was resolved that the kind offer of Dr. Skeel be accepted with thanks.

OBJECTS EXHIBITED.

1. Peristome of Moss, *Funaria hygrometrica*.
2. Peristome of Moss, *Mnium undulatum*.
3. Spores and antherozoids of *Chara*.
4. *Podura*, entire insect.
5. Embryo Oysters.

6. Section of fresh-water Pearl from Norway.

Exhibits Nos. 1-6 from the Cabinet of the Society.

7. Sections of cast skin of Chameleon, *Iguana*, showing two principal layers of the same: by L. RIEDERER.

8. Photomicrographs: Gonococci in leucocytes of human

blood, $\times 500$; Tubercles of tuberculosis in masses attached to walls of human veins; Head of Tapeworm, *Tænia serrata*, showing double row of hooks; Section of bud of Tiger Lily; Transverse section of petiole of *Aspidestris*; Sclerotic cells in pith of stem of *Hoya carnosa*; Transverse section of stem of *Helianthus*; Longitudinal section of stem of Lima Bean: by F. D. SKEEL.

9. Pond-life: by A. D. BALEN.

10. Glass slips with engraved monogram: by H. G. PIFFARD.

Dr. Piffard explained the engraving of his glass slips as accomplished by a loop of platinum wire heated to incandescence by electricity, and used as a pen in writing.

Dr. E. G. Love stated that he marks glass slips by means of a rubber stamp charged with diamond ink—hydrofluor-silicic acid.

MEETING OF NOVEMBER 3D, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-five persons present.

Messrs. Thomas S. Nedham and Chas. W. Plyer were elected Resident Members of the Society.

The following were appointed by the chair as Committee on Annual Exhibition: Messrs. Henry C. Bennett, Thomas B. Briggs, and L. Riederer.

Dr. Alexis A. Julien read a paper entitled "On Uniformly Stained Cover-Preparations of Micro-organisms free from Distortion." This paper was illustrated by exhibits, as noted in the programme below, and by a demonstration of the method of mounting, and is published in this number of the JOURNAL, p. 1.

The paper was discussed by Mr. Henry C. Bennett and by Drs. H. G. Piffard and F. D. Skeel.

OBJECTS EXHIBITED.

1. Amœboid decorated with a garland of cladothrix.
2. Flagellated vibrios (n. sp.) with stained flagella.
3. Living spirilla of Beggiatoa—the largest known.
4. Amœboid resembling *Diffugia*.

5. *Spirillum* of Beggiatoa, showing stained flagella.

6. *Arcella*, with pseudopodia projecting.

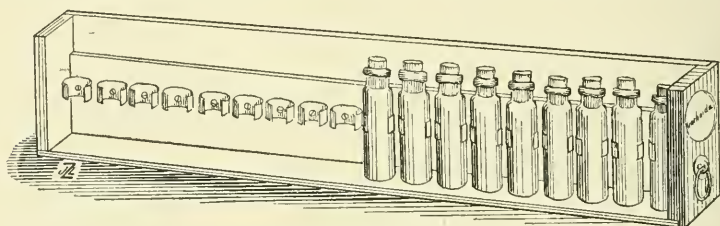
Exhibits 1-6 by A. A. JULIEN.

7. Living *Volvox globator* : by C. S. SHULTZ.

8. Photomicrographs: *Podura*, entire ; *Navicula rhomboides*, $\times 2,000$, taken with a lens of extreme under-correction. The same, taken with a Spencer $\frac{1}{10}$, N. A. 1.35 : by H. G. PIFFARD.

9. Home-made, convenient trays for bottles containing microscopical specimens : by J. L. ZABRISKIE.

Mr. Zabriskie explained his trays as follows : Four trays of a set are here exhibited, each tray being eleven and one-quarter inches long, one inch wide, and two and one-half inches high, all being intended to stand upright, closely adjoining each other, on the shelves of a cabinet twelve inches in depth



Tray for small bottles.

inside. The bottom and the one side of each tray are made of white wood one-eighth of an inch thick ; the rear end of white wood one-quarter of an inch thick ; and the front of walnut three-eighths of an inch thick. This thin wood may be purchased of hardware dealers who supply scroll-saw material; the white wood at about four cents a square foot, and the walnut at about twelve cents. The entire inner surface of each tray is pasted with white paper, the reflected light from which allows the easy and rapid examination of an entire set of bottles while in position, by means of a hand lens.

These trays each contain seventeen one-drachm homœopathic bottles. Each bottle is held in place by a brass spring clip claspings the bottle near the middle. The clips are made from soft, thin sheet brass, cut in oblong strips about one-quarter of an inch wide and one and one-quarter inches long, of such size

that, when they are bent round, they enclose about two-thirds of the circumference of a bottle. Each brass strip has a hole punched in the centre, through which is passed a screw, one-quarter of an inch long, for holding the clip in position in the tray. These spring clips hold the bottles with sufficient firmness to prevent the bottles from falling out, and still to allow any one bottle to be extracted and replaced easily without disturbing any of the others.

An additional piece of white wood is inserted behind the bottles, one-eighth of an inch thick, and as long as the long side of the tray, but of such width that it reaches from the bottom of the tray only up to the necks of the bottles. Wood more than one-eighth of an inch thick would appear clumsy for such small trays. This additional piece of wood, which is scarcely noticeable behind the bottles, together with the thickness of the brass, prevents the screws, one-quarter of an inch long, from passing entirely through the wood and projecting at the outer side of the tray. Screws less than one-quarter of an inch long would be too small to handle with convenience.

If larger bottles are needed, larger trays and larger clips must be employed. Some of the specimens exhibited are preserved in dilute alcohol and others in dilute glycerin. But the arrangement is equally convenient for dry specimens in bottles, as diatomaceous material, etc.

An easily interchangeable label is very desirable for such a collection. The method here exhibited can be recommended for ease of construction and satisfaction in use. A slight circular cavity is bored in the face of the front piece of each tray with a centre bit, seven-eighths of an inch in diameter; a disc of white paper is dropped into the cavity; and the paper is retained in position by a single coil of brass wire, which has sufficient spring to resist falling out from any accidental jar, and yet will allow of easy extraction by means of the finger nail, in order to insert another label.

A convenient draw pull, to extract any tray from the cabinet, is made with a three-eighths inch brass screw ring, the screw of which is passed through a small washer, and inserted in the front of the tray below the label.

When all are arranged in a cabinet, any one of a thousand bottles can be quickly selected and extracted.

MEETING OF NOVEMBER 17TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-seven persons present.

The Corresponding Secretary read a paper by Mr. K. M. Cunningham, of Mobile, Alabama, entitled "Notes on some Researches among the Diatomaceæ." This paper is published in the JOURNAL, vol. ix., p. 85.

Mr. Cunningham donated to the cabinet and for distribution dry diatoms stained blue, and a packet of the "moss-like plant" referred to in the paper.

OBJECTS EXHIBITED.

1. Section of foot of human embryo: by HENRY C. BENNETT.
2. Photomicrographs: Gonococcus, $\times 900$; Spirillum of Beggiatoa, $\times 2,000$, showing hyaline membrane surrounding the spirillum: by H. G. PIFFARD.
3. Photomicrograph of group of *Pleurosigma*, by Powell and Lealand's $\frac{1}{16}$ dry objective, supposed to show great diffraction: by F. D. SKEEL.
4. Living *Volvox globator*: by CHARLES S. SHULTZ.
5. Mounted specimens of the same: by CHARLES S. SHULTZ.
6. Circulation in *Nitella*: by A. D. BALEN.

Dr. Piffard donated to the cabinet the photomicrograph of Spirillum of Beggiatoa, and twelve slides prepared by Thum.

Mr. Shultz distributed living specimens of *Volvox* among the members.

MEETING OF DECEMBER 1ST, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Sixteen persons present.

Dr. John A. Fordyce was elected a Resident Member of the Society.

The following Committee on Nominations of Officers was appointed by the chair: F. W. Devoe, William E. Damon, F. D. Skeel, A. Woodward, William G. De Witt.

OBJECTS EXHIBITED.

1. Diatoms from Croton water in November, 40 forms: by H. G. PIFFARD.
2. Living specimens of *Ophryolegna* sp., from human urinary tract: by H. G. PIFFARD.
3. Two photomicrographs of the same: by H. G. PIFFARD.
4. Diatoms from "Queen Silver Polish": by H. G. PIFFARD.
5. *Amphiprora conspicua*, var. *pulchra* Van Heurck, and other forms, from Harlem River: by J. D. HYATT.
6. Diatoms from Honey Meadow Brook, Dutchess Co., N. Y.: by J. D. HYATT.
7. Diatoms from "Silver Polish," under a William Wales $\frac{1}{13}$: by J. D. HYATT.
8. A fruiting fungus on a photographic film: by J. L. ZABRISKIE.
9. Section of lung of dog, injected: by FRANK ABBOTT, JR.
10. Section of kidney of cat, injected: by FRANK ABBOTT, JR.
11. *Spirillum undula*: by FRANK ABBOTT, JR.
12. Anthrax bacillus in liver of rabbit: by FRANK ABBOTT, JR.

Of his exhibit *Ophryolegna*, Dr. Piffard said that these ciliated infusoria had been preserved alive for ten days in distilled water, and were now exhibited in the same medium; they were furnished by Dr. F. Tilden Brown, of this city, who obtained them from the discharges of the urinary passages of one of his patients; that they had been submitted to Dr. Alfred C. Stokes, who determined them as an undescribed species of the genus *Ophryolegna* Ehrb.; and with regard to the photomicrographs of these organisms, that they illustrate the remarks of Dr. Julien at the last meeting respecting the difficulty of mounting delicate organisms without distortion. These photomicrographs show distortion of two kinds—after slow and rapid death.

Dr. Brown, present at the meeting, said that these organisms are found when shreds are cast in pus-laden urine; the shreds come probably from a more remote source than the urethra; the organisms resist the action of slightly acid urine; and that he and Dr. Piffard both saw what they took to be conjugation in some of these organisms.

Mr. Hyatt said of his exhibits of diatoms that this *Amphi-*

prora was common in tide pools of Harlem River; that Dr. Van Heurck gives a figure of the diatom, and the locality as "Harlem River, New York"; that the diatoms of Honey Meadow Brook arise in warm weather as a scum, consisting quite purely of diatoms, one field, as then under the microscope, showing fifty species of the following genera: *Navicula*, *Cyclotella*, *Cymbella*, *Surirella*, *Gomphonema*, *Cocconeis*, *Synedra*, *Achnanthes*, and *Fragilaria*; and also that the "Silver Polish" in question affords multitudes of diatoms, some of them very fine test objects.

Mr. Zabriskie explained his exhibit of fungus as follows: This photograph is a dry-plate lantern slide, one of a set of about one hundred made from negatives by Mr. Leffert Leferts, taken by him on a trip to Mexico in the fall of 1889. These slides were neatly mounted with mat and cover, and were securely bound with gummed strips around the edges. They were at first frequently used in the lantern, but have been left undisturbed for about one year and one-half, stored in a velvet-lined box on the second floor of the maker's residence. Having occasion to examine them recently, he observed on the film of many of them white, radiating, dendroid patches, one-half of an inch in diameter or less, like some form of crystallization.

On examination with the microscope it was at once seen that each patch was a matured fungus, consisting of white hyphæ, radiating with more or less regularity from a centre, and furnished with numerous branchings, gradually decreasing in size to the attenuated tips. With a magnification of 250 diameters numerous clusters of elliptical, light-brownish spores were found, lying detached upon the film in the neighborhood of the delicate extremities of the branches.

This slide was submitted to Mr. J. B. Ellis, of Newfield, N. J., and from his reply this is probably an undescribed species of fungus. He says it is near *Botrytis reptans*.

MEETING OF DECEMBER 15TH, 1893.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-three persons present.

The President announced the death of Dr. Paul Hoffman, a Resident Member of the Society, which event occurred on the 1st inst., and appointed the following committee to formulate action of the Society: Dr. F. D. Skeel, Mr. J. D. Hyatt, and Rev. J. L. Zabriskie.

Mr. William E. Damon, of the Committee on Nominations of Officers, reported for said committee, nominating the present Officers of the Society for re-election to their respective offices in 1894.

OBJECTS EXHIBITED.

1. A simple centrifuge for separating urinary sediment, diatoms, etc.: by H. G. PIFFARD.

2. A Leitz loup, of excellent definition and unusually large field, recently manufactured by Craft on Steinheil's plan: by H. G. PIFFARD.

3. Section of oölitic chert from Dutchess County, New York: by J. D. HYATT.

4. Section of a variety of the same, from the same locality: by J. D. HYATT.

5. Section of oölitic chert from Pennsylvania: by J. D. HYATT.

6. Micrococci in canaliculi of human tooth: by FRANK ABBOTT, JR.

7. Spirillum in canaliculi of human tooth: by FRANK ABBOTT, JR.

8. Transverse and longitudinal sections of the seed of *Phytelphas macrocarpa* Ruiz and Pavon, Ivory nut: by J. L. ZABRISKIE.

9. Transverse section of the seed of *Smilacina racemosa* Desf., False Solomon's Seal: by J. L. ZABRISKIE.

10. The fungus *Aecidium adoxæ*, on the leaf of *Adoxa moschatellina*: by HENRY C. BENNETT.

11. Cyclosis in *Anacharis*: by A. D. BALEN.

12. Circulation in *Daphnia*: by A. D. BALEN.

13. Helices of fine wire for supporting cover-glass preparations: by F. D. SKEEL.

Dr. Frank Abbott explained that the centrifuge exhibited was manufactured by Ernest Leitz, of Wetzlar, Germany, and he demonstrated its action by rotating the instrument for about

one minute, after having inserted a test tube containing urine, and then exhibiting the deposit in the bottom of the test tube.

Mr. J. D. Hyatt remarked on his exhibits that the material belonged to the silurian age, and was formed in shallow seas by the grinding of calcareous matter, acquiring the oölitic form from the concretions of varying colors depositing around a nucleus, and being rolled upon beaches; that in exhibit No. 3 the nuclei are usually minute grains of sand, with the spheres of generally uniform size, and the structure between the spheres like chalcedony; in exhibit No. 4 the nuclei are minute particles of organic matter, with the crystallization radiating from the nuclei, giving the appearance of hornstone; and that the specimen No. 5, from Pennsylvania, has its nuclei of carbonaceous matter with remarkably uniform spheres.

Mr. Bennett explained his exhibit as follows: The slide contains two preparations, opaque and transparent, of the fungus *Æcidium adoxæ*. The opaque preparation shows the peridia in various stages of growth, and the transparent preparation shows a perpendicular section through a burst peridium. The fungus is found in the spring and summer on the under side of the leaf of *Adoxa moschatellina*—Hollow-root—a little, inconspicuous plant, 4 or 5 inches high, growing in woods and moist, shady places in cooler regions. The pale, green flowers have a musky smell, whence its common name, Moschatel.

Dr. Skeel donated for distribution samples of wire helices, of his own construction, for supporting cover-glass preparations.

PUBLICATIONS RECEIVED.

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CORRECTION.—It is due Mr. K. M. Cunningham to state that, in his article, "Notes on some Researches among the Diatomaceæ," published in this JOURNAL, vol. ix., p. 85, by the omission of certain matter contained in his manuscript he is caused to appear as contradicting his own claim of making the first record of "the motility of the protoplasmic covering of the *Amphiprora*." The omission occurs on page 107, immediately preceding the sentence, "One is certain of witnessing a phenomenon that has for many years been of mysterious interest to observers." In this sentence he refers to the cyclosis in *Nitella* and similar organisms, and not to "the activity of the protoplasmic sheath of the *Amphiprora ornata*" of the preceding sentence, as published.—ED.

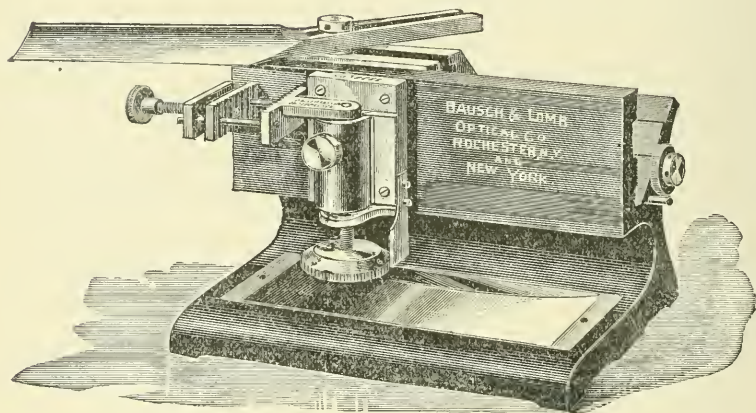
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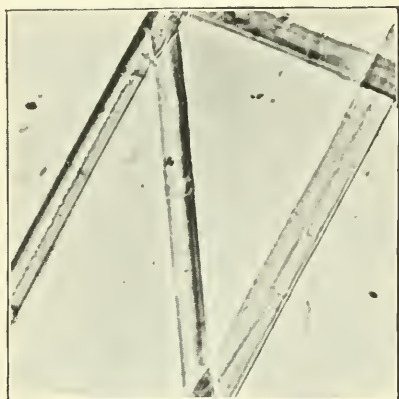
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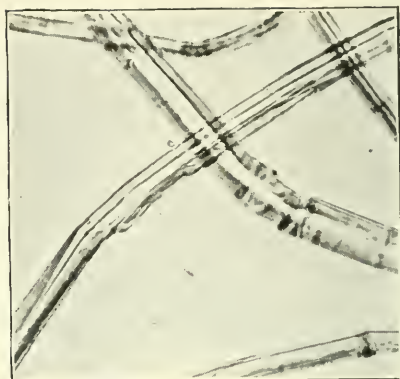
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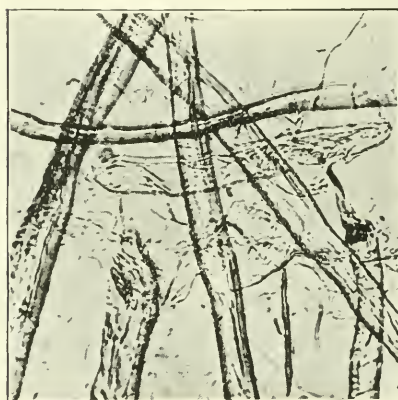
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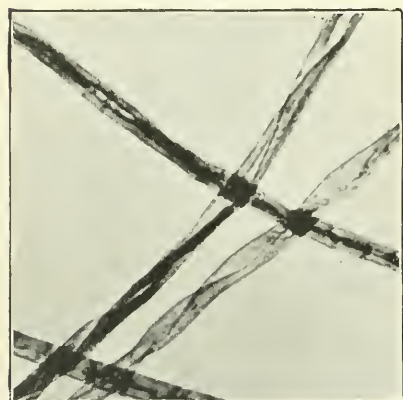
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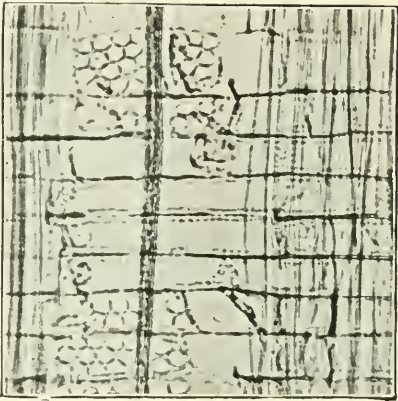


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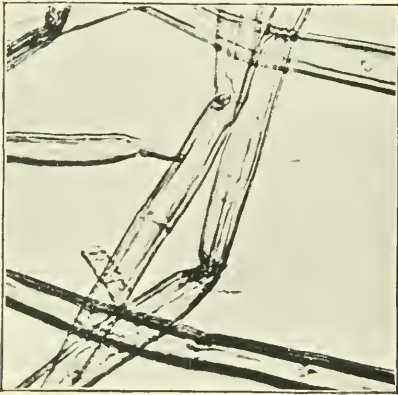


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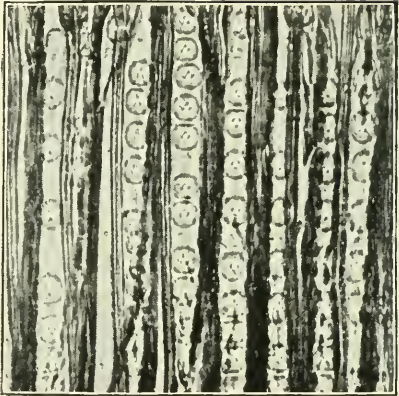
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VOL. X.

APRIL, 1894.

No. 2.

A MICROSCOPICAL AND CHEMICAL EXAMINATION
OF THE ADMIXTURES AND ADULTERATIONS
IN PAPERS USED FOR WRITING
AND ENGRAVING.

ANNUAL ADDRESS BY THE PRESIDENT, CHARLES S. SHULTZ.

(*Delivered January 5th, 1894.*)

In my brief inaugural before the Society last January I spoke of the importance of the microscope as a means of detecting adulterations in food products, fabrics, etc. At that time I incidentally mentioned that a friend and myself had begun the examination of fine papers for a certain purpose.

Explanation of Plate 39.

FIG. 1.—Flax. From a fine example which was used in spinning at Flatbush, Long Island, in 1821.

FIG. 2.—Linen fibre. Ready for paper-making.

FIG. 3.—Linen paper. Extracted from a Michigan Central R. R. bond dated 1872.

FIG. 4.—Letter paper. Water-marked "Royal Irish Linen." Proves to be a mixture of some linen and much cotton.

FIG. 5.—Sea Island cotton. Shows twist in the fibres, but is not sufficiently enlarged to show any diagonal plaid structure.

FIG. 6.—The "Suspected Paper." Purported to be linen, but it proves to be a mixture of some linen, much cotton, some poplar-wood fibre, etc.

Explanation of Plate 40.

FIG. 7.—Longitudinal-radial section of the wood of *Populus monilifera* Ait., exhibiting the peculiar screen-like blocks of the medullary rays noticed in specimens of paper made from the pulp of this wood.

FIG. 8.—Poplar-wood fibre pulp. Made by "soda process."

FIG. 9.—Longitudinal-radial section of spruce wood.

FIG. 10.—Spruce-wood fibre, pulped. "Sulphite process."

FIG. 11.—Reputed "cottonseed-hull pulp." Proves to be fibre of coniferous wood.

All the figures are enlarged about 250 diameters.

The reason of this examination was that my friend, Dr. T. B. Stillman, professor of analytical and applied chemistry at the Stevens Institute of Technology, in Hoboken, received from a firm of engravers a specimen of paper which had been offered to them as "linen paper," suitable for some of their purposes. They wished Dr. Stillman to make a hasty determination of the paper and report as to its constituents. He undertook to do this by chemical means, but, on account of a similar reaction by nearly all vegetable fibres composed of cellulose, his analysis proved unsatisfactory to himself. He looked over many written authorities upon the investigation and manufacture of fine paper, and concluded that chemistry alone would not solve his difficulty, and that, if the constituents were to be fully determined, the microscope must be brought in to complete the analysis.

He asked me to assist him in the case, as he was not an expert in the handling of the microscope. I, who had never undertaken the systematic examination of paper, however, consented to aid him in the analysis of this, which we shall call our "suspected paper." Like many microscopists, I had casually examined fibres of linen, cotton, silk, etc., and had in a general way run through sections of various woods; but when at this time I undertook to examine various papers and paper pulps, I, for want of experience, found myself entirely "at sea." This "suspected paper" seemed to more particularly puzzle us. It had in its appearance much of the straight-fibred characteristics of linen, but it also showed cotton, and in the tangled mass upon the slide other matter cropped out with which I was unacquainted. In short, after making numerous examinations and comparisons with several woods and a variety of papers and pulps, we arrived at the conclusion that this "suspected paper" was composed of a little linen, much cotton, and some wood, mainly poplar; it having probably been largely made up of old or repulped paper, heavily sized and nicely finished. I have but a small piece of this paper here, which I offer for examination.

Up to this period I was not aware of the use of so large an amount and variety of woods in the manufacture of writing and other of the finer papers, supposing that merely newspapers, books, and printers' common stock were made from wood pulps. Much less did I know of the various misrepresentations of the

paper trade until later, when, to my surprise, we found high-class paper manufacturers, both in this country and in Great Britain, who water-mark their products as "Pure linen stock," "Royal Irish linen," "Pure parchment, one hundred per cent chemical fibre," and other high-sounding names, employed admixtures of cotton and various woods, more particularly spruce, some varieties of poplar, fir, white pine, etc., as may be seen by slides Nos. 4-6 and several which are not numbered (Plate 39, Figs. 4 and 6).

Having made this discovery, and now being upon our guard, in order to ascertain what was published upon this topic we looked up some of the literature upon the proper means of detecting admixtures in paper.

We could find but little that was very definite or of much value in the English or American works, but found much in German concerning investigations in progress, although these investigations were usually conducted by intricate and tedious processes.

The work in this line performed and in progress in the German Kais. Königl. Versuchstation at Berlin appears to be the most valuable that came to our notice. Of these I have made a few extracts, which I will give further on if time permits.

The various modern processes in pulping a variety of the vegetable fibres, and the admirable texture and finish given to many of the finer manufactured papers, make it very difficult to get a qualitative, much more a proper quantitative, analysis of these products.

It might be well at this stage to submit a brief outline of the general manner in which paper is manufactured, in order to have you comprehend why it is so difficult to distinguish, in this progressive age, the superior all-linen stock from the cheaper mixtures of cotton, woods, etc. At the head of the list stands the ancient papyrus, of which the first was probably made in Egypt from a species of reed belonging to the family of Cyperaceæ, or sedges. A fine paper was also early made from the inner layers of the cuticle of the mulberry and other trees, laid side by side, and a second layer being placed at right angles; all were wetted, pressed together and dried in the sun, beaten smooth with a mallet, and polished with a piece of ivory or shell.

The Aztecs made a kind of paper from the leaves of the maguey plant, which plant is still grown extensively in portions of Mexico; but the modern Mexican prefers to brew from this plant his "pulque," the national beverage, and his paper is now made from other substances, much like our own.

To the Chinese, however, has been attributed the manufacture of the first paper made upon modern principles, viz., that of pulping vegetable fibres.

My attention was called to a work in German and published in 1887, entitled "*Die mikroskopische Untersuchung des Papiers mit besonderer Berücksichtigung der ältesten orientalischen und europäischen Papiere*," by Dr. Julius Wiesner, professor of botany and vegetable physiology in the University of Vienna.

This book, a quarto of eighty-two pages, is mainly intended as a history of paper-making, and gives the constituents of writing papers manufactured from the ninth to the nineteenth century, showing the earlier papers to consist of more or less wool mixed with hemp and linen; and later, as made in the eleventh to the fifteenth century, a mixture of wool, linen or hemp, and cotton, heavily sized with glue or starch, prevailed; and in the fifteenth century the use of wool in paper ceased.

After this, according to this author, the European papers were made of linen and small quantities of cotton combined, but in the early part of the present century cotton was used in larger quantities as an adulterant of linen and hemp papers. Later on cotton was used as the sole ingredient of the cheaper writing papers.

This author gives the names of many letters and public documents from which paper has been taken and examined by himself and others, working together on these historical investigations at this time. He also mentions the labors of Briquet and Caruel in their microscopical researches on papers used from the eleventh to the fourteenth century inclusive.

Among the older papers examined by Dr. Wiesner there are some found in the tombs of Egypt; others from Arabia, Damascus, and other portions of Syria; also many important documents in Italy and of various parts of Europe from one thousand years ago to the present century. In each case he states from what materials these papers are manufactured, gives the title of the

writing or document and the date thereof, making a curious and interesting history.

The usual processes of paper-making are well known, but I will mention enough of them to indicate why it becomes so difficult to detect adulterations and admixtures therein, either chemically or microscopically. The chief reason why we cannot separate the component substances of paper microscopically, is because the linen or cotton rags, or both of these mixed, are placed in the "beating machines," equipped with long knives and flail-like arms, which tear up and beat out all traces of their original textile nature. With protracted maceration in strong alkalies the mass is reduced to a jelly-like pulp. This mass is retained in hot water for many hours, bleached with chloride of lime, sized with gelatin, or resin soap, and alum dissolved in soda. China clay is sometimes added to improve its weight and surface rather than its quality. One would think that these tearing, macerating, and chemical pulping processes would be quite sufficient to obliterate all traces of the original fibres; but when to this is added old paper to be reworked, then the difficulty of optically separating the original fibres becomes extremely aggravated, so that while one knows upon microscopical examination that he has not pure linen paper before him, he nevertheless finds himself embarrassed in determining what he sees in the broken-up and tangled mixture, however carefully he may arrange it upon the slide. You may demonstrate this for yourselves by looking at slide No. 6, this being our "suspected paper" which was offered for linen (Plate 39, Fig. 6).

When, however, a percentage of wood pulp ready for paper-making is mixed with linen, or linen and cotton pulp, and especially if the wood is of the coniferous order, such as spruce or white pine, etc., then the woody admixture is quite easily discerned, although it may have been cut to pieces and pulped.

In slide No. 8 you will see a fair example of a spruce-pulp paper by one of the chemical reductions, known as the "soda process" (Plate 40, Fig. 8).

Now as to the modes of manufacturing wood pulps for paper-making.

There are two general methods, one known as the "mechanical" or "ground wood," and the other as the "chemical" pulp

process. These are again subdivided into "sulphite," "soda pulps," etc. By the "mechanical" or ground-wood method any suitable wood is taken, usually, on account of cheapness, the edgings, slabs from sawmills, small cordwood, and other waste stock. In the "Voelter" process, which is German, the defiberer, or mill, consists of a coarse cylindrical stone revolving rapidly, against which the pieces of wood are held by springs. The water which flows through assists in reducing the fibre so finely that the subsequent chemical treatment is simple. The "mechanical" processes, however, break up the fibres into short particles, thereby reducing the strength of the pulp and permitting less of this pulp to be mixed with linen or cotton, on account of the consequently greater friability of this woody matter.

Among the various "chemical" wood-pulp processes is one in which the wood is not disintegrated, as by the "mechanical" or ground-wood methods, but convenient-sized pieces are placed in a steam-tight vessel and boiled with about twenty per cent of strong caustic soda under a pressure of ten to fourteen atmospheres. In another, by the popular "Mitscherlich" patent method, bisulphite of lime is used instead of soda; and the best wood pulps are prepared by the several "sulphite" processes.

I show you here several examples of these methods in sheets of dried pulp, and finished papers, Nos. 12 to 17, with the color action of various reagents upon them, which were treated by Prof. Stillman, and which I will explain after I shall have finished this paper. The mounted slides of the corresponding numbers are on the stands for your inspection.

Now, as if the several methods of paper-making, as briefly described, were not sufficiently destructive, there is still another curious mode—that is, the converting of cane wood into pulp. By this, the "Lyman" process, the disintegrated cane is placed in strong iron cylinders, called "guns"; these are about twenty-two feet long and twelve inches internal diameter, and are laid on heavy frames. The heads are fastened on both ends, and steam is admitted until a pressure of one hundred and eighty pounds to the square inch is reached. This pressure is maintained for about twelve minutes, when, by pulling a trigger, the covers are suddenly released, and the steam, propelling the mass of disintegrated wood before it, rushes out with an explosion equal to that of a large

cannon and may be heard many miles. The charges from these "guns" are fired against an iron target about thirty feet distant, leaving a spongy mass which is then converted by chemical treatment into paper. Besides the mangling of paper stock by the various pulp-making methods, there are still the several processes of finishing, such as bleaching, sizing, and moulding the pulp by means of wire gratings, upon which the setting or hardening pulp rests; a portion of these screens, with figures or names placed in them by means of thinner wires, producing the "water-markings" commonly seen on writing papers.

In addition to these we have the calendering, glazing, filling, and numerous other finishing processes, with which I will not further weary you.

Having now seen these several constituents of paper variously torn, cut, beaten, mangled, shot out of "guns," ground up, dissolved by chemical means, and many of these substances completely transformed from their original condition and the appearances with which we are familiar, how are we to determine what they are? When we consider the great variety of materials used in the manufacture of paper, and yet know that all of them consist of cellulose, which gives a similar reaction chemically, we find that the chemist is debarred from positively identifying any admixture of pulps or finished paper, although he can detect "mechanical" wood pulp unmixed, as we shall see later, by the color demonstrations on the papers, as heretofore mentioned and here exhibited; but beyond this stage chemical tests become unreliable.

We see, therefore, why almost the entire determination of admixtures in paper rests with the microscopist.

It is easy to recognize under the microscope the ordinary materials from which paper is manufactured, such as linen, cotton, various woods cut in thin sections, etc., when each of these substances is in its natural condition and properly mounted for microscopical observation.

Here are displayed before you under magnification not only preparations of the actual materials—flax, cotton, etc.—but also a number of photomicrographs of the same preparations distinctly exhibiting the details (Plate 39, Figs. 1, 2, 5; Plate 40, Figs. 7, 9). In addition to these examples of the simple fibres

you will also see here illustrated in the same manner the more intricate specimens of various pulps for paper-making, composed of linen, cotton, mechanical and chemical wood processes, besides one slide purporting to be "cottonseed-hull pulp," but which instead proves to be of coniferous wood, as you will readily see from its well-known characteristics (Plate 40, Fig. 11).

Let us go a little further and examine the finished papers, portions of which we have here upon our slides. Previous to mounting these Dr. Stillman prepared them for the purpose of eliminating the sizing, rosin, filling, etc., with which they were finished. This is accomplished in this manner: Cut the finished paper in small pieces, and place them in a beaker, adding a sufficient quantity of a solution of caustic soda (caustic soda one part, water thirty parts). Digest the paper just below the boiling point for about fifteen minutes. Pour off the liquid and replace with double the quantity of distilled water. Pour off this water and wash once again in the same manner. Add the same quantity of a solution composed of fifteen parts of distilled water to one of hydrochloric acid. Digest ten minutes with a gentle heat. Pour off this liquid and wash in warm distilled water about three times, then dry the paper for mounting in glycerin or balsam. In order to get some contrast in the fibres for photographing, stain them lightly with hæmatoxylin.

As an example of pure linen paper shown here, and which is becoming somewhat scarce in the market, I have extracted a specimen from a railroad bond now twenty-two years old (Plate 39, Fig. 3). We have here also a specimen of a sheet which is water-marked "Royal Irish Linen," a letter paper sold at a good price. Inspect this under a microscope, and you will have no difficulty in finding a fair proportion of cotton mixed therein (Plate 39, Fig. 4). In the slide (No. 6) already mentioned as from our "suspected paper" you will see scattered through it but little linen, and will see some woody indications, with plenty of cotton; but, on account of the tearing-up, pulping, and repulping process it has undergone, it will be found very difficult to eliminate the various disintegrated fibres therein contained. The sheet from which the specimen on slide No. 13 was taken is called by the manufacturer "parchment paper." I regret to have mislaid this sheet. This was a strong, nicely glazed, and

highly finished paper. From its name and general appearance one would think it might be pure linen paper, but you will find nothing but cotton in the specimen under the microscope. We have not known any attempt of the manufacturer to palm off papers made wholly of wood for linen, but the several kinds of wood pulps are frequently mixed with linen and cotton-rag pulps, and when finished are sold for high-class paper, while the cheaper grades are made almost entirely from wood pulps.

Both in the "mechanical" and "chemical" wood paper systems the woody markings may be distinguished by the aid of the microscope, and more particularly the coniferous fragments (Plate 40, Figs. 10, 11).

Poplar-wood fibre, when torn up, somewhat resembles cotton, but there is at least one distinguishing feature, even among the disintegrated "mechanical" pulps—that is, the tangential fragments have among them particles bearing a grate- or screen-like appearance; some of these evidences may be seen in slide No. 7, a section of the wood of *Populus monilifera* (Plate 40, Fig. 7). Slide No. 16, being paper of the Singerly Pulp and Paper Co., also exhibits this peculiar feature, indicating poplar wood "ground" up by the "mechanical" process. Slide No. 17 is of Woolworth & Graham's "ground wood pulp," which also shows a little of the poplar character, but the mass is so full of short fibre as to be practically unrecognizable, and is only fit for printers' low-grade work. The chemical tests, however, show plainly by their peculiar colors that this is "ground wood."

We have here a sheet of dried pulp from Norway, called "Eker," which is shown by the microscope to be composed of spruce wood, and, as you will see by its bright-red color in its chemical reaction, when I slightly touch it with para-phenylenediamine hydrochlorate, is proved to be "mechanical fibre."

I will not go into further detail regarding the varieties of paper intended for the higher classes of work. It is patent that there is much yet to be learned about the methods of detecting mixtures in paper, even for the ordinary qualitative tests; and as for quantitative analysis, we have found no better method than those adopted at the German testing station at Berlin, where an eye-piece micrometer, ruled in squares, is used to count, as best may be, the several fibres or parts of fibres of each admixture con-

tained in any square or number of squares, and by this means to arrive at the average proportions of each kind of material contained in the mass.

A glance through the microscope at some of these paper compositions will, I think, satisfy you that, even after making many measurements and taking the average of them, the final determination will be far from correct, on account of the thoroughly intermingled condition of the various substances; the differences in the dimensions of the divers kinds and shapes of the fibres; the broken portions of many of these; as well as the impossibility of discriminating between the ingredients in their disintegrated state. For the reasons given I have not, up to this time, attempted a quantitative determination in mixed or adulterated papers. For similar reasons no fixed rule can be laid down for optically separating the constituents in the finer papers, except by long and diligent practice with the microscope, thereby training the observer's eye and mind for the discrimination necessary in detecting such matter as one finally becomes familiar with by certain details he has previously recognized, and by comparison with the elements which form the component parts of the usual admixtures or adulterations named in the subject of this evening.

I am thankful to Prof. Stillman for bringing this matter to my attention originally; for the valuable aid he has given me in his chemical preparations; for collecting examples of paper stock; and in pointing out much of the bibliography bearing upon this class of investigation. You are also indebted to him for the color reactions which he has so well shown, by means of the numerous examples of pulps and paper treated by him which I have laid before you, and which I will briefly explain when I apply some of these reagents to show you their rapid action on some papers.¹

We are under obligations to Dr. E. G. Love for the photomicrographic illustrations of many of the slides upon the tables, which enable us to more readily conceive the appearances of the

¹ On account of the chemical investigations by Prof. T. B. Stillman, now in progress and relating to papers and their constituents, I do not mention at this time any of the other chemical reagents shown here, but hope that he will in the near future give for publication, in a chemical or other technical journal, a more complete means of chemical identification than has hitherto been known.

several original substances here shown, and the results when these are made into pulp and paper, as I have already described.¹

I regret that I am unable to throw more light upon what we have discovered to be an intricate and vexatious subject; but if no further advantage shall be attained from our earnest efforts at this time, I hope, at least, that other members will be induced to take up not only the further investigation of paper admixtures, but also the analysis of many of the familiar products manufactured and in common use, with a view of making known to the world what adulterations they severally contain.

Moreover, I have chosen a utilitarian theme on this occasion whereby the microscope is applied to the economic arts; may I be pardoned, therefore, for the lack of truly scientific work which might be expected in an annual address before such an association as ours? If no other benefit shall result therefrom, we as microscopists, when engaged in kindred lines of research where science is applied to the practical arts, may perhaps disprove the imputation that we can claim no independent position in either the arts or sciences.

¹ Of the numerous photomicrographs made by Dr. Love, we have had portions, two inches square, cut from eleven of them, and reproduced in half-tone by the photo-engraving process, and inserted in this publication in two plates.

THE COMPARATIVE ANATOMY OF THE VERTEBRATE SKIN.

BY GEORGE WILLIAM KOSMAK.

(Read January 19th, 1894.)

I. Introduction.

The subject to which I ask your attention this evening presents to both biologist and microscopist a varied and fascinating line of work in original research and investigation. In its morphology and physiology many points are still doubtful and obscure, awaiting the biologist's explanation and elucidation; while to the working microscopist there is held forth an equal opportunity in a field where little satisfactory work has yet been done—*e.g.*, in the technique and new methods of sectioning and staining.

The study of the skin, anatomically and physiologically, is a subject vast and extensive, with an accompanying literature equally so. The latter, however, consists of a mass of detail, much of which is unimportant. The beginner must wade through

Explanation of Plate 41.

FIG. 1.—Diagram of Fish Skin. Transverse section, illustrating general structure. (After *Wiedersheim*.) S C, striated cuticular border of epidermis; A, slime cells; E, epidermis; D, derma; K, goblet cell; L, granular cells of *Petromyzon*; B, blood vessels; V, vertical connective-tissue bundles; H, horizontal connective-tissue bundles.

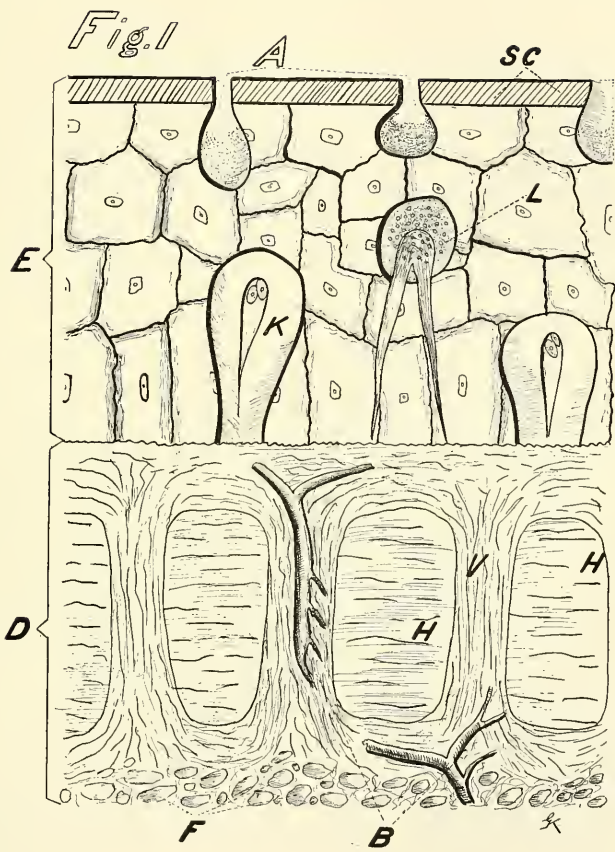
Explanation of Plate 42.

FIG. 2.—(a) Diagrammatic cross-section of skin of larval Salamander; (b) ditto, of adult form. (After *Wiedersheim*.) E, epidermis; D, dermis; S C, striated cuticular border of E; C, stratum corneum; M, stratum Malpighii; P, pigment; O, subcutaneous layers of muscle; B, blood vessels; N, epithelium of glands; X, Y, integumentary glands; T, muscles of glands.

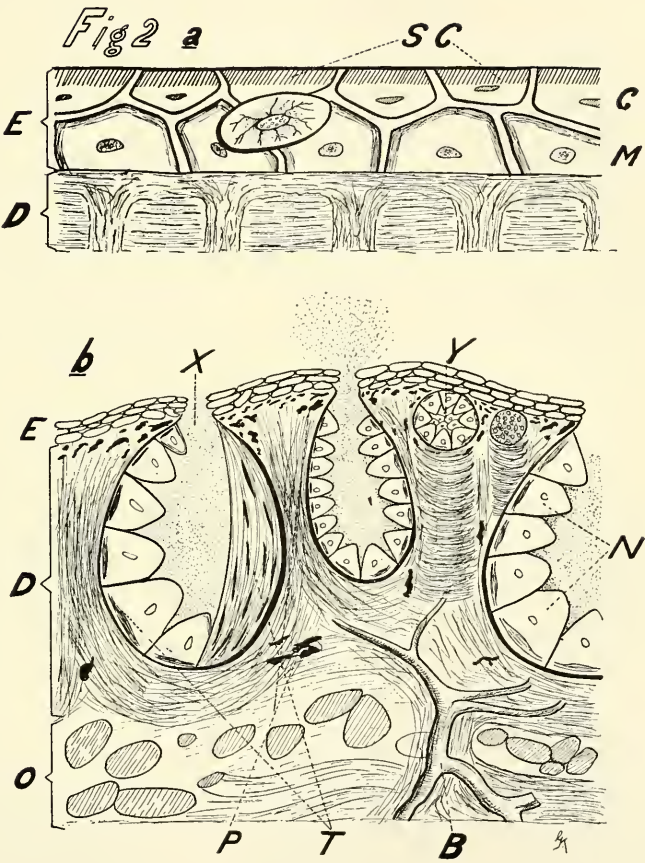
Explanation of Plate 43.

FIG. 3.—Feather Development. Diagrammatic. (After *Studer*.) *a, b, c, d, e, f* denote successive stages. C, stratum corneum; M, stratum Malpighii; D, derma; F, F', feather germ; P, pulp; Q, quill; B, barbs; B', barbules. *c* is a cross-section of the feather germ in *b*, showing the ridges of Malpighian cells covered by the horny layer of epidermis.

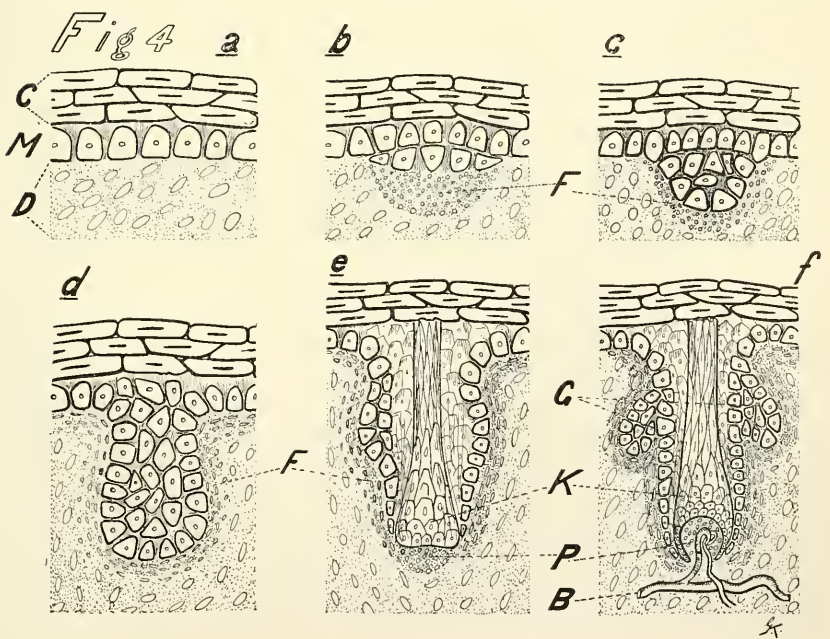
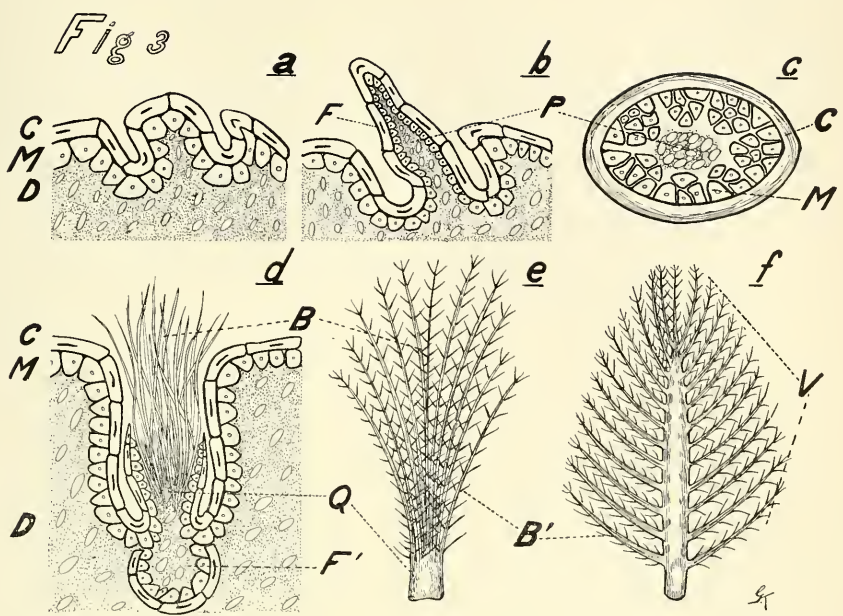
FIG. 4.—Hair Development. Diagrammatic. *a, b, c, d, e, f* denote successive stages. C, stratum corneum; M, stratum Malpighii; D, derma; F, hair follicle; B, blood vessels; K, hair knob; G, sebaceous gland; P, hair papilla—in *e* and *f* are indicated two stages in its formation; in *f* it has become vascular.



VERTEBRATE SKIN.



VERTEBRATE SKIN.



VERTEBRATE SKIN.

it all, as there is no general work on the subject that I have yet found—no manual which treats of the anatomy and physiology of the skin in a comparative sense, with a section devoted to microscopical methods. The need for such a work is evident.

Owing to this magnitude I can only speak of generalities. I will first say a few words of the skin in general ; then take up the several types of vertebrates, and speak of their most characteristic structures as derived from the skin ; and finally make brief mention of the theories of homologies and correlations that have been noted in the higher types.

II. The Skin in General.

The vertebrate skin, as derived from the embryo, consists of two layers, a superficial ectodermal and a deeper mesodermal layer. The former is called the *epidermis* (scarf-skin), the latter the *dermis* (corium or cutis). The skin, like a mucous membrane, consists of an epithelium resting on a connective-tissue basis, the epithelium forming the *epidermis* made up of a few or many layers of cells. The surface of the *dermis* is thrown up into a number of elevations, called papillæ, which differ in form, size, and complexity in different regions of the body and with the position in the animal scale. The epidermal or outer layer does not follow this papillary contour of the dermis, and when the two layers are carefully pulled apart and examined (*e.g.*, in the human skin) the papillæ appear to plunge into and be covered by the more even epidermis, although the outer surface is well marked by ridges and furrows, such as we can plainly see in the palm of the hand. These papillæ are the end organs of that most important sense, *touch*, and in the lower forms may also function as other sense organs, which will be spoken of later on.

The outer or epidermic layers always consist of cells only, while the derma is made up also of connective-tissue fibres, as well as of elastic and contractile elements. In the epidermis two layers can always be distinguished—an outer, composed of horny cells, and therefore called the *stratum corneum* ; and an inner, made up of soft protoplasmic cells, the *stratum Malpighii*. The latter really serves as a matrix for the regeneration of the outer, horny layer, the superficial part of which is continually scaling

off. Nerves, glands, pigment cells, bony structures, and blood vessels occur principally in the dermis. So-called epidermic structures, such as skin glands, hairs, feathers, nails, hoofs, claws, bristles, etc., are formed from the epidermis or outer layer. These will be treated of in those types in which they are most characteristic, and we can then also see how environment, both natural and artificial, has brought about many changes both in their form and function. This need not appear strange or wonderful when we consider how accessible the outer surface of the skin is to external modifying influences. Before beginning with our types of animal life and illustrating the modifications that occur, the two primary divisions of the skin must be borne in mind—an outer layer, protective, and an inner layer, nutritive in function.

A few words in regard to the general physiology. Broadly speaking, the waste products of the body are *urea*, *carbon dioxide*, *water*, and various *salts*. These leave the body by one or other of three main channels: the *lungs*, the *kidneys*, or the *skin*. The lungs discharge most of the carbon dioxide and some water; the kidneys, the urea and allied bodies; the skin, a small amount of the salts and nearly all the water. The skin is therefore the great evaporating agent, and the discharge of waste products by this channel we know as perspiration or sweat.

It has been proven that death would ensue in an animal in which this cutaneous evaporation was prevented by covering its body with an impermeable varnish which retained the sweat in the glands, which thus acted as a poison.

The skin in the lower forms can also take the place of lungs. If the lungs of a frog be removed he will continue to live for some time, consume oxygen, and produce carbon dioxide, as in the ordinary mode of breathing, thus showing that respiration can be carried on efficiently by means of the skin.

Having briefly noticed its main anatomical and physiological features, we will now take up the skin comparatively in the five great classes of the vertebrates, and examine its most prominent characters in each.

III. The Classes of Vertebrata.

A. Fishes.

In certain members of this class we find conditions which have undoubtedly been inherited from invertebrate ancestors. Thus in the outer epidermic layer of many Fishes (*Amphioxus*, e.g.) we find a striated border, which can be imagined to consist of coalesced cilia, and in the larval condition we find the free-moving cilia themselves on the outer surface of the epidermis (Fig. 1, S C). Here, as in many other instances, we can see gradual transitions from lower to higher forms.

Glands, such as we find in higher vertebrates, are usually not present in Fishes. The skin secretions which we do find come from single cells or canals (Fig. 1, A). The fluids which they contain probably protect the skin from the action of the water or ward off the attacks of fungoid growth; and it has lately been determined that certain of them function also as sense organs. Other secreting cells are also present, the so-called "*goblet cells*" (Fig. 1, K), whose function has not been definitely determined.

The most marked characteristic of the integument of Fishes is in the scales. These lie in connective-tissue pouches of the derma, and are formed as ossifications of the latter. In the higher types of Fishes they are covered by the epidermis throughout life, but in *Ganoids* (Gar-pikes, etc.) and *Elasmobranchs* (Sharks and Rays) this is only the case in the larva. In the adult they are free and projecting. The primitive form of the common fish scale, as we see it in the Perch, for example, was probably an ossification in the derma, which we call the basal plate with projecting processes, the *derm denticles*. The transitions which these have undergone from one form to another constitute a very interesting series. In many Fishes, especially fossil, they form a complete protective armor by their fusion, as in the well-known armored South American catfishes.

The next factor to consider is pigment. This always originates in the derma, and to it is due coloration. In endeavoring to account for its presence in the epidermis it has been asserted and observed that white blood corpuscles carry pigment granules to the outer layer, where they take on amœboid movements, and then break up into many small pigment-containing particles,

which are taken up by the epithelial cells. The distribution of pigment over the body varies with the species and individual. It is also subject to changes in environment, and is under direct control of the nervous system. That it changes in order that the animal may adapt itself to its surroundings, has lately been demonstrated in the case of the common English Sole. As is well known, the color of its upper side approximates very closely the tint of the muddy bottom upon which it lives. However, when placed under conditions which permit the access of light to the lower as well as the upper side of its body, pigment will also be developed on that side which formerly showed no trace of it.

We now take up a very important derivation of the integument—*sense organs*. Their main function is probably the perception of mechanical irritations of the surrounding water, but they may also have to do with the perception of sound. As elements we have two kinds of cells: rod-shaped sensory cells, connected by nerve fibres with the central nervous system, and the supporting cells, which lie between the others and serve as connecting and isolating material. The surrounding medium is always kept moist by various secreting cells. In those animals which give up an aquatic life in the course of their development and come to live on land, the end organs of the nerves pass further inward, the rod-shaped cells disappear, and we have two kinds of nerve endings in the skin: terminal ganglion cells and free nerve endings. With Fishes we must include Amphibia in the consideration of these sense organs, as the two types are very closely related. "They consist of a central mass of cells, arranged in the form of a rounded and depressed pyramid, and of a peripheral mass grouped around the former. The central cells are in connection with nerve fibres, and each bears on its free end a stiff, cuticular hair; these are to be looked on as the proper sensory cells, and the others merely as a supporting medium." Where these hairs project freely from the epidermis they are surrounded by a delicate, protective, hyaline tube, which opens into the surrounding water, and into one end the sensory hairs project. These organs are at times distributed over the whole body, but as a rule only in certain well-defined tracts; those along the sides from the head to the tail form the so-called organs of the lateral line. Others are found in depressions or canals formed by scales, and

then, of course, the protective hyaline tube disappears. Another form of sensory organs are the end bulbs, which in Fishes serve as tactile organs, but in higher forms develop into organs of taste.

B. Amphibia.

The skin of Amphibia, as in the Salamander, exemplifies a transitional stage from Fishes to Reptiles. Thus, in the aquatic larval forms, two sharply differentiated layers of the epidermis can be made out, the superficial one with that same striated cuticular border which we find in Fishes (Fig. 2, S C). Later, with advancing development, the layers of the epidermis become more numerous, involutions toward the derma take place to form a great number of globular and tube-shaped glands (Fig. 2, X, Y, N). This richness of glands is a marked feature of the skin of Amphibia, and to it they owe their moist and slippery nature. Their secretions serve a variety of purposes, from merely supplying moisture, to a protective function in the form of poison.

Pigment is deposited in great quantities, partly in and partly between the cells of the derma. Here, as in other forms, we see that wonderful adaptation to environment, as exemplified in the well-known green tree-frog and the sandy-colored horned toad of our Western deserts.

Calcifications may also occur in the derma, but they were more abundant in fossil than in modern forms. Some of the integumentary sense organs of this group have already been mentioned in connection with those of Fishes. Another form, which is first met with in the tailless Amphibia (*Anura*), is the tactile spot, consisting of a group of cells in a typical form of papilla, which functions as an organ of touch.

C. Reptiles.

In taking up this group for examination we notice two prominent characters: the formation of scales and other horn-like structures, and the almost total absence of integumentary glands. Scales can here be dismissed with a few words. They are all formed by a change in the epidermis, in which the derma takes part later on. Many widely differing forms all originate in this manner, and can be classed in general with the feathers of birds

and the hair of mammals. The scales and rattles of snakes, the tortoise shell of chelonians, claws, prickles, and warts, are all epidermal.

In this group pigment plays an important rôle. The chameleon is a time-honored and well-known example of the change of color to agree with surroundings. In addition to pigment the formation and structure of the scales in relation to the light-rays may also have something to do with the general effect.

Integumentary sense organs are represented in Snakes, and also in Birds, by tactile cells surrounded by connective-tissue pouches, with septa separating the individual tactile cells and thus forming a tactile corpuscle.

Dermal ossifications were more developed in ancient reptiles than in those of the present day. Crocodiles, some lizards, and principally the chelonia, still maintain dermal structures.

D. Birds.

When we come to examine this group the most characteristic integumentary structures are the feathers, and these will therefore require the greater part of our attention.

Ordinarily feathers appear to be inserted over the entire body of a bird, but on closer view they will be found, with but few exceptions, in certain regions only, called *feather tracts*, separated from each other by naked stretches of skin. These tracts vary in number and position with different genera, as do also the shape and size of the individual feathers. In a general way feathers develop as follows: At the point where one is destined to be formed occurs a slight upheaval of the dermal tissue, followed by the epidermal layer, and thus creating a papilla. As this papilla grows outward and forms a bluntly-pointed cone (Fig. 3, *a*), its base sinks gradually inward; the epidermis immediately surrounding follows and forms a pocket around the elongated papilla. This papilla is the *feather germ* (Fig. 3, *b*, F), and the pocket constitutes the *feather follicle* (Fig. 3, *b*). The papilla is thus made up of the two layers of the epidermis on the outside, acting as a covering for the mass of dermal cells in the interior, the *pulp* (Fig. 3, *b*).

As the feather germ grows the cells of the inner epidermal or Malpighian layer increase rapidly in number, and grow toward

the centre of the germ in a series of ridges, thus forming folds between them which run the length of the *germ*. Immediately surrounding this is the outer, horny layer of the epidermis (Fig. 3, *c*). Each separate ridge of these internal cells now becomes horn-like, and the central pulp substance dries up. We thus have a bundle of horny rays surrounded by an outer sheath, and of these the pencil-like structures seen on the bodies of newly-hatched birds consist. The outer, horny covering finally breaks off, the rays or barbs become free, and a *down-feather* is formed (Fig. 3, *d*). The lower portion remains in the skin as the *quill*, and the entire structure may remain or be replaced by definite feathers. In such case a second germ forms at the base of the first, the papilla grows rapidly, undergoes nearly the same changes as the other, the embryonic down-feather is pushed out and may often be found attached to one of the barbs of the new feather. At first the two kinds are much alike, but, in the second, one of the rays becomes rapidly thickened and forms a *stem*, to which the barbs are attached on each side, with their *barbules* (Fig. 3, *f*). This theory of feather development, as advanced, with perhaps some slight differences of detail, by Studer (1873) and Kerbert (1876), has been, and is to a great extent even to this day, accepted as the simplest and most probable.

In Birds we have no trace of true dermal bones, and also a marked deficiency in glands, the only ones being the uropygial glands at the base of the tail, whose secretions serve to oil the feathers. Many important epidermal structures, in addition to feathers, are found in this group; such are: claws, spurs, foot scales, and beak sheaths.

E. Mammals.

We now come to the highest class of the vertebrata, and, as in Birds, we will consider first its most prominent feature—namely, hair. Histologically this is quite distinct from the hair-like structures of Birds and Reptiles, which have no true hair. Its development is very interesting.

At the spot where a hair is to be formed an increase in the number of cells of the inner epidermal or Malpighian layer takes place, forming a dome-like mass directed toward the interior (Fig. 4, *a*, *b*, *c*, *M*). The cells of the derma now arrange them-

selves in mantle form around this mass in a kind of pocket, destined later to become the outer hair sheath. This proliferation of Malpighian cells now assumes a bottle-shaped form, and a differentiation of the constituent cells into central and peripheral portions takes place (Fig. 4, *e*, F, K). The central part consists of elongated cells and grows rapidly outward to form the *hair shaft*; the peripheral layer now becomes a *sheath*. The base of the shaft will now be observed to have assumed a knob-like form; an infolding of its base occurs to contain the nutrient blood vessel (Fig. 4, *e*, *f*, K, B, P). Sebaceous glands for oiling the hair are also produced by proliferations of the Malpighian cells (Fig. 4, *e*, *f*, G). When a shedding of hair takes place a new papilla may be formed at the base of the old one.

Hair plays a very important part in the life history of the Mammalia. It is their most distinguishing characteristic, and here, as much as in any animal type, we can see the great protective value of integumentary derivations, the very nature of the hair mass retaining so large a quantity of the heat of the body.

When pigment is present in Mammals, it occurs in the cells of the Malpighian layer, showing a marked difference from lower forms where it is found principally in the derma.

Epidermic structures are worthy of note in this group. They include many and varied forms: the baleen plates of whales, the spines of the hedgehog and porcupine, the nasal horns of the rhinoceros, the claws of cats and dogs, the bristles of the hog, and many others all belong in this category.

The principal glands are sweat and sebaceous glands. These make up two general classes, the former the simpler, the latter more highly developed histologically. The mammary glands, which characterize this group, can be also looked upon as modified sebaceous glands.

IV. Conclusion.

The five great types of back-boned animals having been examined, it remains for us to consider briefly a few of the relations of the integumentary structures to general organic evolution and to each other.

In the first place, as we have seen, they are divided into two classes: those originating in the derma, in which the epidermis

may or may not take part, and those developing from a purely epidermal source. Fish scales and derm denticles are examples of the former; in the lower types they form a complete exoskeleton; but as we ascend in the animal scale it is found that as the endo-skeleton becomes more highly developed this exo- or dermal skeleton grows of less and less importance, until finally it disappears altogether. Epidermal structures (hairs, feathers, e.g.) have now become of greater value. It seems that with the higher development of the internal skeleton and the degeneration of dermal structures the epidermal derivatives have grown in importance.

Scales, feathers, and hairs are undoubtedly derived from a more primitive, common condition, for in their individual developments they show many points of resemblance. The intermediate form between reptile-scale and bird-feather has not as yet been found; but feather and hair both point to one antecedent type, found at the present day in the spurs of birds and the hair of Monotremes. For in *Echidna* we find a hair without any medullary substance, and then succeeding stages to typical hair. The spur is very likely descended from a hair with a thickened outer layer. This structure may break up into rays and form a feather, or become flattened out to form a scale.

The relations of these structures to each other have furnished material for many theories, but we still await the final and definite settlement of the question. This is but one of the many problems which constitute such a fascinating field of research to the modern biologist, who can accomplish wonders if he would but attempt to elucidate and harmonize, or else disprove and expunge, some of the many theories of his predecessors regarding these questions.

IN MEMORIAM.

REV. SAMUEL LOCKWOOD, PH.D.

Dr. Lockwood died at his residence, Freehold, N. J., on January 9th, 1894, in the seventy-fifth year of his age.

He was born at Mansfield, England, on January 20th, 1819, and was brought in his infancy to New York City, where he received his education, graduating from the New York University

in 1847. During his university course he accepted the position of assistant editor of the New York *Sun*, offered him by the editor, Mr. Moses Y. Beach. Taking a theological course at the Theological Seminary of the Reformed Dutch Church, at New Brunswick, N. J., he graduated from that institution in 1850; received his ministerial license the same year from the Classis of New York; and immediately entered upon his first pastorate in the Reformed Church at Cortlandtown, Westchester County, N. Y. which position he held until 1852. He then filled successive pastorates in Reformed churches, at Gilboa, N. Y., from 1852 to 1854, and at Keyport, N. J., from 1854 to 1869.

In 1867 he was appointed Superintendent of Instruction for Monmouth County, N. J., and for a more central position in this field of labor he moved his residence to Freehold in 1870. It was in this office, which he held until the time of his death, that he rendered service in behalf of public education which will long be remembered for its faithfulness and efficiency.

An interested student of nature from his youngest days, he possessed the enthusiasm, patience, and assiduity which especially succeed in exploring and interpreting the secrets of wonder and beauty veiled from the careless crowd. He took delight in announcing to others what he had learned, as is evidenced by his numerous publications during many years in scientific serials of this and foreign lands, and by his numerous addresses before scientific bodies of our own country.

During his pastorate at Gilboa, Schoharie County, N. Y., he made a special study of the local geology, which resulted in discoveries confirming opinions of the grandeur of the Devonian period, and in a notable palæontological collection, now at Rutgers College, New Jersey. It was of this collection that Prof. George H. Cook, afterward State Geologist of New Jersey, is said to have exclaimed, on displaying it before the students: "If Hugh Miller were living he would want to cross the Atlantic to see it."

At Keyport, N. J., he found a different but no less fascinating field of nature spread out before him, which he enthusiastically cultivated, and in relation to which he issued various noted publications on palæontology and marine zoölogy. It was during this period—1867—that the New York University conferred on him the degree of Doctor of Philosophy.

Dr. Lockwood was an expert microscopist, using his knowledge of the instrument especially in lines of public instruction and benefit. He was one of the founders of the New Jersey State Microscopical Society, and for some years its President. He was elected an Honorary Member of the New York Microscopical Society in 1884, and his interest and zeal in the welfare of this organization are evidenced by his many instructive and valuable addresses, and by his presentation of objects through these years very nearly to the close of his course.

He was possessed of admirable traits of character. Integrity, good-will, and firmness have left him an irreproachable record. His extending knowledge and facile, accurate expression have made him a desired leader and manager of affairs in his lines of duty. Reverence guiding his enthusiastic unfoldings of nature always tended to point the hearer to the Creator. And a kindly disposition, pervaded by a vein of humor, made him a desirable companion. His death will leave a void in the hearts of many acquaintances and friends.

PROCEEDINGS.

MEETING OF JANUARY 5TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-one persons present.

Annual reports were presented by the Treasurer, Librarian, Recording Secretary, Corresponding Secretary, and the Committee on Publications.

The committee appointed December 15th, 1893, to formulate action on the death of Dr. Paul Hoffman, reported as follows: "Since it has pleased Providence to take from us our friend and fellow-member, Dr. Paul Hoffman, we desire in this manner to express our deep sense of sorrow, and to extend to the bereaved relatives our sympathy."

Mr. Arthur G. Elberg and Dr. Ferdinand G. Kneer were elected Resident Members of the Society.

The President read his Annual Address, entitled "A Microscopical and Chemical Examination of the Admixtures and Adul-

terations in Papers used for Writing and Engraving." This address was illustrated by numerous objects and photomicrographs, as noted below, and is published in this number of the JOURNAL, p. 31.

This being the stated meeting for the annual election of officers, the President appointed Mr. William J. Lloyd and Dr. Anthony Woodward tellers, and at the closing of the polls the following persons were declared elected officers of the Society for 1894 :

President, Charles S. Shultz.
 Vice-President, Edw. G. Love.
 Recording Secretary, George E. Ashby.
 Corresponding Secretary, J. L. Zabriskie.
 Treasurer, James Walker.
 Librarian, Ludwig Riederer.
 Curator, George E. Ashby.
 Auditors { F. W. Devoe.
 W. E. Damon.
 F. W. Leggett.

OBJECTS EXHIBITED.

1. *Bacillus tuberculosis*, under a one-quarter-inch objective of his own construction : by F. D. SKEEL.
2. A "Bulloch Stand" made by E. B. Meyrowitz : by F. D. SKEEL.
3. Flax, from a fine example used in spinning at Flatbush, Long Island, in 1821.
4. Linen fibre ready for paper-making.
5. Linen paper extracted from a Michigan Central Railroad bond dated 1872.
6. "Royal Irish Linen" paper containing a large proportion of cotton.
7. Sea Island cotton.
8. The "suspected paper," purported to be linen, but containing linen, cotton, and wood.
9. "Eker" paper from Norway.
10. Sections of wood of *Populus monilifera* Ait.
11. Poplar-wood pulp, "soda process."
12. Sections of spruce wood.

13. Spruce fibre pulped, "sulphite process."
 14. "Cottonseed-hull pulp." Proves to be fibre of coniferous wood.
 15. Eleven photomicrographs of the above fibres, taken by Dr. Edw. G. Love.
- Exhibits Nos. 3-15 by CHARLES S. SHULTZ.
-

MEETING OF JANUARY 19TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-five persons present.

The following committees were appointed by the Chair :

Committee on Publications : J. L. Zabriskie, William G. De Witt, Walter H. Mead, John L. Wall, Charles F. Cox.

Committee on Admissions : H. W. Calef, Anthony Woodward, M. M. Le Brun, H. G. Piffard, W. J. Lloyd.

The President announced the death of Rev. Samuel Lockwood, Ph.D., Honorary Member of the Society, and appointed the following committee to formulate suitable action under the circumstances : F. W. Devoe, J. L. Zabriskie, H. G. Piffard.

The Recording Secretary read a letter from Mr. F. W. Devoe referring to the death of Dr. Lockwood, and also an extract from the *Monmouth County Democrat* on the same subject.

Mr. George William Kosmak read a paper entitled "The Comparative Anatomy of the Vertebrate Skin." This paper was illustrated by very fine enlarged colored diagrams, and by objects under microscopes, as noted below, and is published in this issue of the JOURNAL, p. 42.

OBJECTS EXHIBITED.

1. Human blood, eosin stain, under the one-quarter-inch objective exhibited at the last meeting : by FRANK D. SKEEL.

2. Section of leaf of Syrian Wheat, showing trichomes : by FRANK D. SKEEL.

3. Transverse section of skin of Dog-fish with derm denticles projecting.

4. Transverse section of skin of young Sturgeon with derm denticles dropped.

5. Vertical section of *Necturus*, showing glandular developments.

6. Feather germ of Chick at nine days.

7. Vertical section of human scalp, showing roots of hairs.

Exhibits Nos. 3-7 by GEORGE WILLIAM KOSMAK.

Dr. Bashford Dean stated that one of the most important discoveries in this line announced during the past year was that by Miss Julia C. Platt, professor at Mt. Holyoke Seminary, to the effect that the head cartilage is derived from the ectoderm of the embryo.

MEETING OF FEBRUARY 2D, 1894.

The meeting was held in Hamilton Hall, Columbia College. The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons were present.

On motion the routine business of the Society was deferred until the next meeting.

Dr. Alexis A. Julien read a paper entitled "A Silicified Form of a New Species of Fungus in Wood from the Petrified Forest near Cairo, Egypt." This paper was illustrated by numerous excellent photographic lantern views, and by objects under five microscopes, consisting of mineralogical sections, prepared with remarkable carefulness and skill by Mr. T. B. Briggs to exhibit the desired characteristics of the material referred to in the paper.

MEETING OF FEBRUARY 16TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons present.

On motion it was resolved that the proposed amendment of the By-Laws be laid on the table.

On motion it was resolved that a committee of five be appointed by the Chair to report on amendment of the By-Laws. The following persons were so appointed: Messrs. William G. De Witt, Walter H. Mead, Horace W. Calef, Dr. Frank D. Skeel, Dr. Edw. G. Love.

On motion it was resolved that the above committee be instructed that, if the By-Laws are not explicit on this subject, they

arrange for the plain statement therein that ladies are eligible to resident membership in the Society.

OBJECTS EXHIBITED.

1. Blood of *Amphiuma*, double stained: by FRANK D. SKEEL.
 2. Crystals of monobromide of Naphthalin: by CHARLES S. SHULTZ.
-

MEETING OF MARCH 2D, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Eighteen persons present.

Mr. Francis R. Wardle was elected a Resident Member of the Society.

OBJECTS EXHIBITED.

1. Transverse section of hair of Whale: by CHARLES S. SHULTZ.
2. Transverse section of hair from tail of Elephant: by CHARLES S. SHULTZ.
3. Hair of Horse with eggs and larva of Bot-fly *in situ*: by CHARLES S. SHULTZ.
4. Polyzoon, *Fredericella*, showing statoblasts *in situ*: by HENRY C. BENNETT.
5. Cuticle of *Equisetum*, polarized: by FRANK D. SKEEL.
6. Photomicrographs: Transverse section of stipe of Fern; Transverse section of petiole of Floating Heart, *Limnanthemum*; "Brush and Comb" of Ant; Scale of Eel; "Tongue" of Cricket; Section of Chalcedony; Crystals of Magnesium Sulphate in balsam; Crystals of Morphia Sulphate in balsam.

Dr. Skeel stated, concerning his exhibit, that the Japanese use the stems of *Equisetum* for polishing wood, and also the cuticle of the same, stripped off and inserted in pieces of bamboo, for nail-files, from one of which his specimen was taken.

Dr. Skeel also referred to the late interesting article by Mr. Wenham in the *English Mechanic* on measuring the aperture of lenses, illustrating his remarks by blackboard diagrams.

MEETING OF MARCH 16TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-one persons present.

Messrs. Charles Du Vivier, George R. Du Vivier, and Mrs. Maria O. Le Brun were elected Resident Members of the Society.

The committee appointed with reference to the death of Dr. Samuel Lockwood reported, and the report was accepted and adopted.

Dr. Carlton C. Curtis read a paper entitled "A Contribution to the History of the Formation of the Lichen Thallus." This paper was illustrated by excellent camera drawings, and by objects under microscopes, as noted below.

On motion the thanks of the Society were tendered Dr. Curtis for the paper so presented.

The Corresponding Secretary presented donations to the Cabinet and for distribution among the members from Mr. K. M. Cunningham, of Mobile, Alabama: 1. Chalk, polished, from Waco, Texas, bank of Brazos River; 2. Polished section of limestone from Austin, Texas; 3. Lignite from Mobile Bay, Alabama; 4. Complex crystalline sand from Whistler, Alabama; 5. Green glass slips for examination of the sand; 6. Silicious bodies, designated "*Phytolitharia*."

The donations were accompanied by the following communication from Mr. Cunningham, dated March 13th, 1894:

"I forward to the Society a few specimens illustrating some studies in micro-geology, and which I believe possess some interest microscopically.

"1. A prepared specimen illustrative of a portion of the cretaceous area of Texas. It is an indurated form of chalk found by myself outcropping on the eastern bank of the Brazos River, at Waco, Texas, the stratum underlying the town of Waco.

"Chalk is an earthy carbonate of lime, consisting almost entirely of microscopic shells of foraminifera. There are several special forms of chalk—as the soft, friable, and very white chalk of commerce, derived especially from the celebrated chalk cliffs of England; and, again, as comprised in a very extensive area of the cretaceous belt of the Southern States, notably in Tennessee, Mississippi, and Alabama. I have been deputed by the State Geologist to investigate and report upon the chalk area of the latter State. And the interesting results of an examination of chalk strata from some thirty different points in Alabama, enabled me to record in the State Report on the Cretaceous Rocks

the occurrence of forty species of foraminifera, representing nineteen genera of the foraminifera of the chalk deposits of the globe. These species were identified through the kindness of Anthony Woodward, Ph.D., of New York City. For this purpose I prepared two slides containing, arranged in lines, some one hundred and twenty-five shells each.

“One face of the specimen of Waco chalk is polished in such manner as to exhibit the sections of the various shells and spicular particles, all of which may be seen under a one-quarter-inch lens. By abrading the chalk with a brush while moist, thousands of the perfect crystalline shells may be isolated and studied in their integrity.

“2. A section of limestone, polished on both sides, showing an exceedingly rich aggregation of microscopic Rotuline shells of one species, which in their transverse sections are concave on both faces, similar to the assumed cross-section of a blood corpuscle. This limestone occurs as a stratified formation, and is quarried at Austin, Texas, for the manufacture of lime, and for constructive and monumental purposes.

“3. A specimen of lignite from the shore of Mobile Bay, two miles south of the city, which throws light on the genesis of the coal formations of the carboniferous period. I have already recorded a comprehensive study of this stratum, which will be referred to in the Report on the Tertiary of Alabama.

“The main feature of interest is that when large slabs of the lignite were removed from the water they were as plastic as potter's clay, but they would also readily split into layers, which exhibit the films of ferns and other vegetable impressions. In drying, this lignite shrinks at least fifty per cent in bulk, but preserves the vegetable impressions, which may be readily seen with a low power.

“This small specimen represents the last phase of coal plant deposition, and belongs just under the superficial or pleistocene strata of the tertiary of Alabama. The stratum from which the specimen was derived was heavily impregnated with ferric sulphide, containing myriads of minute golden-hued spherules of pyrite, isolated in quantity by gravity and solution in water.

“4. Packets of a complex crystalline sand derived from the superficial stratum largely capping the argillaceous strata of

Mobile County. A full analytical study of the same has been made for the Alabama Report on the Tertiary.

"The sand has a greater specific gravity than common silicious sands. By the passage of a small magnet, crystalline grains of magnetite and magnetic spherules may be isolated, and when a portion of the sand is spread on a glass slip, and gently tapped to reject all grains which do not adhere, many perfect crystals of siliceous or other vacuoles, and the characteristic colors of the true gems when examined by polarized light. The use of the green glass slips accompanying these packets differentiates the angles, edges, apices, gaseous vacuoles, and minute crystalline inclusions of these grains, in beautiful pink or rose-colored hues against an emerald-green ground.

"5. A packet of curious silicious bodies, designated by Dr. Ehrenberg as '*Phytolitharia*,' to each of which he gave a specific name in his '*Micro-Geologie*,' as if they possessed the same interest as the diatoms and rhizopods usually associated with them.

"These are examined by spreading a thin layer in a dried state under condensed surface illumination, when the characteristic features of each will be noted. If mounted in balsam the stereoscopic character is lost, as all the cylinders, etc., appear flat and of little interest. The differentiating power of the polariscope is well shown on a balsam-mounted slide of these '*Phytolithariæ*.' A few scattering grains of silicious sand and micaceous scales respond to the polarizing power, glowing with prismatic colors, but not one of all the various forms of '*Phytolitharia*.' These '*Phytolithariæ*' are derived from a stratum of swamp clay at Whistler, Alabama, and also from a stratum of bluish plastic clay containing a long series of plant and animal remains, *i.e.*, diatoms, rhizopods, spongy spicules, plant capsules, and spores in endless profusion."

OBJECTS EXHIBITED.

1. The Alga as scraped from trees : by CARLTON C. CURTIS.
2. Longitudinal section of young thallus : by CARLTON C. CURTIS.
3. Longitudinal section of sporocarp : by CARLTON C. CURTIS.

4. Longitudinal section of apothecium : by CARLTON C. CURTIS.
5. Section of Agate from basalt, Paterson, N. J. : by J. D. HYATT.
6. Section of Pitch Stone, Isle of Arran, Scotland : by J. D. HYATT.
7. Cinnabarite, cinnabar in chalcedony with native gold : by J. D. HYATT.
8. Transverse section of stem of Poison Ivy, *Rhus toxicodendron* : by J. D. HYATT.
9. Sections through head and thorax of House-Fly : by L. RIEDERER.
10. Hemlock joist, 2×4 inches \times 2 feet, from lintel of door of outbuilding thirty-five years old, almost entirely eaten away by our native large black ant, probably *Camponotus herculeanus* L. : by FRANK D. SKEEL.

Mr. Hyatt explained his exhibit of *Rhus toxicodendron* by means of blackboard drawings, showing that this stem, when growing unattached, has the pith in the centre ; but when attached to a tree or wall, always has an eccentric growth, the pith lying near the bark on the outer side, and the enlarged rings of growth lying on the inner side, next the object of support, thus indicating that nourishment is derived through the rootlets which cling to the support.

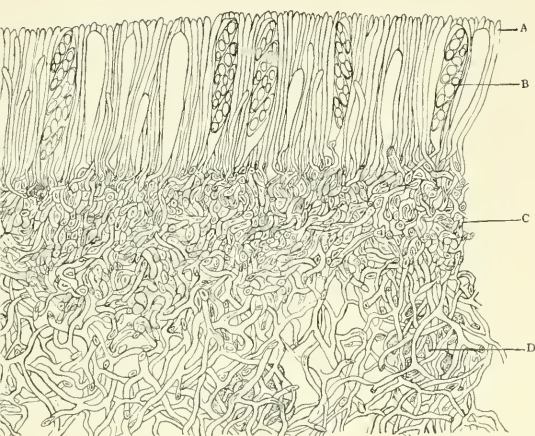
THE MICROSCOPE AND MICROSCOPICAL METHODS. Part I. of The Microscope and Histology. By SIMON HENRY GAGE, Associate Professor of Anatomy, Histology, and Embryology in Cornell University. Fifth edition, rewritten, greatly enlarged, and illustrated by 103 figures in the text. Ithaca, N. Y. : Comstock Publishing Co., 1894. Pp. 165. Price, \$1.50.

This work had its origin in the necessities of the class room. As stated in the preface, "the aim has been to produce a book for beginners in microscopy, such as the author himself felt sorely the need of when he began the study." How well this object has been accomplished, during the evolution of fifteen years to this present edition, is demonstrated with great satisfaction to

the reader, as he examines the successive chapters with their thorough, clear, and masterly exposition of the necessary successive steps in the knowledge of the microscope and its applications. The book is one of the best of its kind : a labor-saving implement to the beginner, in the class room or out ; and to the amateur, who perhaps for years has been feeling his way and attempting in various directions to invent methods of his own, an unspeakable boon in condensing the experience of a host of workers, and bringing this so conveniently at hand where it can be laid hold of at once, as occasion requires. Prof. Gage is to be congratulated on the able manner in which he has improved and augmented the instruction in this volume.

THE BIOLOGY OF FERNS BY THE COLLODION METHOD. By GEORGE F. ATKINSON, Ph.B., Associate Professor of Cryptogamic Botany in Cornell University. Part I.—Descriptive, with 163 illustrations in the text. Part II.—Methods. New York : Macmillan & Co., 1894. Pp. 134. Price, \$2.00.

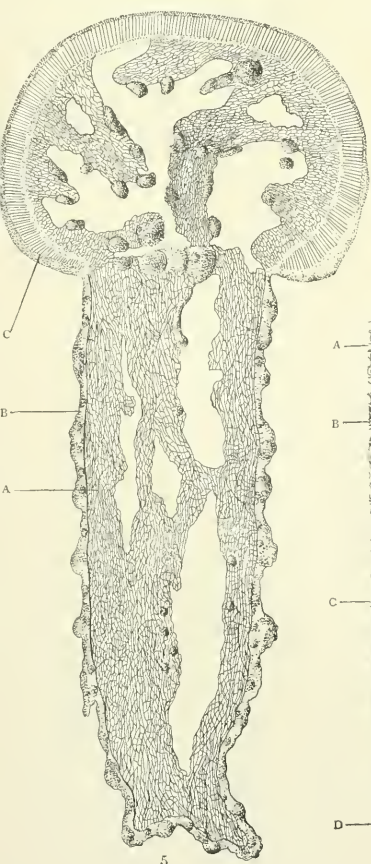
In seven chapters of Part I. of this work the author, in condensed but lucid and satisfactory manner, conducts the reader through the subject of the biology of ferns under two main subdivisions—the gametophytic phase, or the prothallus, with its archegonia, antheridia, and resulting fertilization ; and the sporophytic phase, or that of the popularly known fern proper, from embryo through the examination of stem, root, and frond to the fructification, and occasional sporophytic budding, or production of bulbs. In the eighth and concluding chapter of the same part is a short exposition of the structure of the Ophioglossæ, introduced, as the author says, because they “present excellent subjects for comparative study.” Part II. is an exposition of the technique of the collodion method of infiltration and embedding employed in securing the preparations demonstrating and illustrating the successive steps of Part I. The highest commendation of this collodion method is the statement that it has produced the beautiful and accurate illustrations here displayed. The one hundred and sixty-three illustrations are all original, chiefly by the author ; but the delicate and encouraging compliment of accrediting each pupil as the preparator and draughtsman, when he has so furnished an occasional illustration, is exceedingly refreshing in these days of ordinarily free-hand appropriation of everything within reach considered as advantageous for the occasion. The paper, presswork, and beautiful figures illustrating the logically arranged and instructive text of this publication combine to render it in every respect most admirable. The work is intended primarily as a text book, a guide, instructor, and incentive in the class room for those who have before them the coveted prize—“Ph.D.” But it also gently and invitingly opens the door of access, in view of many an amateur outside the class room, to a department of examination and discovery among the most fascinating in all the domain of botany.



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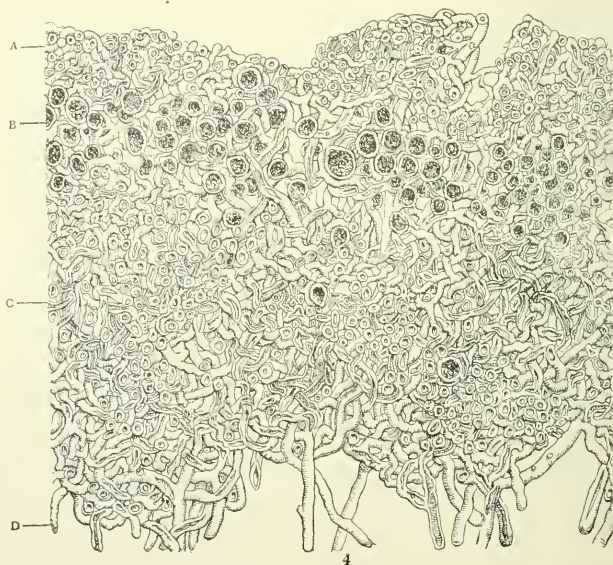
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THE LICHEN THALLUS.

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No. 3.

A CONTRIBUTION TO THE HISTORY OF THE
FORMATION OF THE LICHEN THALLUS.

BY CARLTON C. CURTIS.

(*Read March 16th, 1894.*)

About five months ago some material was brought into our laboratory that proved to be an exceedingly early stage in the development of the lichen thallus. The observations on, and illustrations of, this condition and subsequent development that have extended down to the time of writing are here presented, not as any considerable addition to the subject of lichenology, but because the study awakened much interest among the students, and some points were made clearer than could be gathered from the literature of the subject, and, as far as known, there are no

Explanation of Plate 44.

FIG. 1.—Filament of the fungus attacking an algal cell.

FIG. 2.—The subsequent development of the form shown in Fig. 1. The algal cell has divided several times, and the hyphæ have extended themselves to form a bushy cluster.

FIG. 3.—A still older growth. The clusters are becoming covered above and below with a mass of filaments.

FIG. 4.—A longitudinal section through the young thallus. *a*, Upper medulla; *b*, gonidial or algal zone; *c*, lower medulla; *d*, rhizoids.

FIG. 5.—A longitudinal section through a sporocarp. *a*, The dense tissue of the stipe—the lines are not intended to represent the structure; *b*, the gonidia largely confined to the periphery of the sporophore; *c*, hymenium—the dotted portion representing the paraphyses projecting beyond the asci.

FIG. 6.—A longitudinal section of the apothecium. *a*, Paraphyses; *b*, ascus with spores; *c*, hypothecium—the hyphæ anastomose more than is indicated; *d*, a small gonidial group.

records of this early condition occurring in a state of nature. For, since the time when lichens were styled aërial algæ, down to the time when Schwendener termed them autonomous, so much of error was published that there can be no fear of augmenting this dark but suggestive page of botanical history. On the other hand, the histological work of De Bary¹ and Schwendener,² the analytical researches of Famintzin and Baranetzki,³ and the brilliant and successful synthetic labors of Rees,⁵ Treub,¹⁰ Bornet,⁴ and Stahl,⁶ from their thoroughness and scientific methods, preclude the addition of material truth either to theory or facts of the subject. And in our own day the ingenious investigations of M. G. Bonnier⁷ on the protonema of several mosses should be included as worthy of mention with these latter scholars. Perhaps no department of scientific research can present such a flood of false observation and theory; certainly none can show such dogged resistance to the truth or more brilliant and scientific work in its establishment. These early lichenologists, confining themselves narrowly to their subject and unacquainted with its biological relationship, compiled volumes, tomes, and libraries totally ignorant of the real nature of the subject under discussion. And to them came the truth like the awakening from a dream. They could not at first believe that their work was all a myth, and later would not. And so not till comparatively very recent times, though demonstrated beyond peradventure of a doubt by the histologist and physicist, has the truth been accepted.

When first gathered the material bore a close resemblance to *Protococcus viridis* Ag. as it often appears growing on trees and stones in damp places. But under the glass it aroused the wonder of all who saw it, none the less from its strange and unexpected appearance than from the beauty and elegance of its form. Here could be seen the white, almost hyaline mycelium becoming excessively branched and forming bushy, spherical masses of hyphæ, in whose ultimate ramifications were held the round, emerald-green algal cells (Plate 44, Fig. 2). Not yet were the gonidia obscured by the filaments, and the branching and method of growth were easily followed. In nearly every group could be found one or more algal cells, somewhat removed from the cluster, and showing clearly how they are seized by the

hyphæ. With the formation of each new cell either a branch from the filament encircling the mother cell or from the mycelium is put out to get possession of it. At the moment of union an unmistakable quickening is manifest both in host and parasite. The latter puts out, at a short distance from the alga, from one to several branches that follow the main fibril and encircle the alga in various windings (Fig. 1). The alga greatly increases in size, and the early growth often suggests a strong resemblance to the fingers of a hand closing about a ball. The gonidia often attain a diameter of twenty μ , averaging about nine μ , thus exceeding the size of *Protococcus viridis* Ag. by about two μ . In the more mature thallus the crowding and subsequent distortion give them a somewhat smaller appearance. The activity of the fungal hyphæ was apparently due to the food furnished by the algæ. The increase of the algæ, however, seemed due rather to some stimulus or irritation of the hyphæ than to any food supplied to them. In this early stage it cannot be doubted that the algæ are often removed some distance from the parent cells and become the centres of new clusters, which in fact could be found in all stages of growth, showing from one to many gonidia. These clusters by their increase finally anastomose, forming a more or less entire surface from which the characteristic thallus develops. That this was not the usual method of extension will be seen below, and it was also manifest from the numerous germinating spores that often appeared in the clusters, and also from the tendency of the free mycelium to turn back toward its cluster soon after its exit. While the spore (Fig. 6) was the prevalent one, there also appeared two other forms, some of which had germinated. Owing, however, to the entanglement of the filaments it was impossible to see how extensive was the growth of the odd spores. And the question arises whether the hyphæ of various spores may enter into the structure of a lichen, and the dominant one characterize the resulting thallus. In looking at these clusters of filaments and algæ the thought often occurred that could Crombie have seen them he would not have made so spirited and bitter an attack upon the theory of Schwendener, nor would the latter have appeared so highly colored or poetical to him.⁸

After the young symbionts became accustomed to their new surroundings in the laboratory there soon was manifest the

characteristic structure of the lichen. The groups became covered above with a very dense growth of hyphæ; below, the mycelium kept pace and usually exceeded the growth above, but at the sides rarely did any considerable thickening of the filaments occur. So there was always room, not at the top, but at the sides for the extension of the mycelium with its captured cells. This new lateral extension would be woven over, almost as soon as formed, by the dorsal and ventral hyphal layers. The divisions and growth of the algæ were very rapid in the early stages, and this growth continued at the margins; but as the hyphæ, in the extension of the thallus, entangled them more and more in a dense mass, their activity lessened and finally stopped through the crowding of the surrounding filaments. It was apparent that division only ceased when all the space available to the algæ had been occupied. And so finally the form of the algæ was concealed by the mat of hyphæ above, through whose semi-transparent walls the color still shone. On the under side the thickened mass shut out cells and color alike, thus presenting a whitened surface. From this under side extended numerous strands of the mycelium, rhizoids, into the substratum. These roots were confined for the most part to the median and especially to the distal portions of the thallus, and were of the nature of holdfasts. A cross-section of the thallus (Fig. 4) now shows the hyphæ so closely woven together above as to render the form of the individual fibrils almost indistinguishable. Beneath are the crowded gonidia, forming a well-marked zone in which the original centres of growth are still indicated by group-like masses of algæ, though this latter arrangement is often obliterated by the broadening of the clusters and their consequent union. It will be noticed that scattered algal cells frequently appear in the ventral medulla and but very rarely in the dorsal. Thus again is it manifest that the transportation of the gonidial cells attendant upon growth depends upon their seizure by, and subsequent growth of, one of the hyphæ. The looseness of the subgonidial layer permits at many places of such a limited growth, while above there is rarely opportunity for a fibril with its host to crowd through. Mention should be made here of an exception to this rule. The gonidial zone occasionally extends quite to the upper surface of the thallus. At such places the unimpeded algæ may be carried out by

the hyphæ, forming an irregularity or projection upon the surface, or a branch of the thallus may start from such a point. In some sections there appeared connected with this feature small bundles of gonidia and hyphæ not unlike soredes. These may have been simply the beginnings of further growth. A somewhat similar growth appears on the sporophore referred to below. The peculiar configuration of the thallus that characterizes both the margin and surface of the mature lichen seems to be largely due to the behavior of the mycelium in blocking the growth of the gonidia with mats of filaments. This interposition of dense felts at various places on the margins results in a very irregular, almost ragged, outline of the thallus. I could not always satisfy myself that the lobing, particularly in the young thallus, was brought about in this manner; but its frequent observation leaves little room for doubt that the cause of the peculiar form of growth is as above stated.

The sporocarp appears to arise from a lifting up of the thallus, which, growing into a tubular mass, forms the receptaculum. Though diligent search was made for the archicarp in all these early stages of growth, not the slightest evidence of it could be found. Nor did any section show any trace of or give indication of sexuality. The hypothecium and paraphyses could be recognized at an early age, especially the latter, which appeared about as soon as there was any outward evidence of the sporocarp. The asci appeared much later, and in fact could not be recognized till the hymenium was developed and began to show its characteristic color. In this state the ascogenous hyphæ could not be traced into the subhymenial layer, and, in truth, had the same appearance as the filaments generating the paraphyses. The growth of the asci extended over a considerable period, new sacs appearing beside those apparently empty. The apothecia are spherical, surmounting the stipe like a cape, and of a brown color from the closely packed filaments of the hymenium. The receptaculum shows a marked variance in its structure from that of the thallus. As mentioned above, it is cylindrical, of especially dense tissue, the hollow central portion being traversed by irregular strands from the periphery. But, unlike the thallus, the gonidial layer is largely developed upon the outside. As soon as the filaments of the medulla begin to lift up to form the

stipe, the algæ are carried through to the outer surface and follow in luxuriant growth its upward course. Only a comparatively few scattering clusters occur in the discocarp and cavities and tissue of the stipe. On the periphery of the receptaculum, however, there is an unusual growth of algæ, loosely bound together, and sparingly covered by the filaments. Not a little attention was given to this peculiar development. The ease with which they could be separated, and the simplicity of their growth, readily suggested that they might be means of propagation, though the significance of their position on the stipe rather than on the thallus was not manifest. I can see only one explanation of this distribution of the gonidia—namely, that the algæ are massed along the stipe, exposed directly to the atmosphere, unrestrained in their growth by the pressure of a medulla, in order that they may be able to meet with an adequate food supply the heavy demands made upon their constructive metabolism by the ascogenous hyphæ. This appears to be an excellent illustration in vegetable physiology of adaptation to economic ends. And this seems the more probable as the rhizoids are the last stage in the reduction of root forms. Although the algæ are in a limited degree histological factors of the thallus, being dependent upon the fungi, it may be, for their ash constituents, nevertheless it is more in keeping with the nature and behavior of lichens to look upon the fungus simply as an obligate parasite and the alga as a host. And then again it was often observed that on the old sporophores the gonidial bundles began to grow after the manner first described, and at times quite covered the stipe with small thalli. This secondary growth on the receptaculum was not observed while the asci were still developing.

The results of the consortism of these two plants is particularly worthy of note. On the one hand, the fungus, delicate, a saprophyte, fond of darkness and dampness, and the alga, dependent upon shade and moisture, by their commensalism produce a plant independent of surroundings and organic substratum, capable of living upon crystalline rock or bark of tree or earth, enduring the extremes of heat and cold, neither dependent upon rain nor destroyed by drought. And this complete change of habit is not so striking as the behavior of these two lowly plants as symbionts. They at once catch the spirit that governs all higher vegetable

life, and whatever form they make take, whether foliaceous, fruticose, or crustaceous, they are always actuated by a principle new to their nature—the exposure of the chlorophyll to the light and atmosphere as much as possible. How important a force, then, is this commensalism! What part may it not have taken, fostered by natural selection, in the separation of forms? The behavior of the protonema of mosses and fungi; the transformation by algæ of some of the simpler animals⁹ to forms widely different and independent of organic food absorption; the easy passage of the algæ to purely histological factors in the anatomy of the lichens—all suggest that this force of commensalism may have played a more important rôle and been a more potent factor in the determination of species than is ascribed to it. I am greatly indebted to Mr. A. E. Anderson for the greater part of the drawings. I also wish to acknowledge the valuable advice and assistance of Prof. N. L. Britton in the prosecution of the research work.

1. DE BARY: Ueber die Erscheinung der Symbiose.
2. SCHWENDENER: Ueber den Bau und das Wachsthum des Flechten-Thallus, etc.
3. FAMINTZIN UND BARANETZKI: Zur Entwicklungsgeschichte d. Gonidien und Zoosporenbildung der Flechten.
4. BORNET: Recherches sur les Gonidies des Lichens.
5. REES: Ueber die Natur der Flechten.
6. STAHL: Beiträge zur Entwicklungsgeschichte der Flechten.
7. BONNIER: Germination des Lichens sur les Protonemas des Mousses.
8. KÖRBER: Zur Abwehr der Schwendener-Bornet'schen Flechtentheorie.
9. BRANDT: Ueber das Zusammenleben von Thieren und Algen.
10. TREUB: Lichencultur.

NOTES ON THE STAINING OF CELLULOSE.

BY E. G. LOVE, PH.D.

(Read April 20th, 1894.)

Cellulose forms the basis of vegetable tissues, and also occurs to a slight extent in animal membranes. It is composed of carbon, hydrogen, and oxygen, and its composition is the same as that of starch.

In chemistry the words cellulose and lignin are often used as synonymous terms. It is preferable, however, to restrict the word lignin, as is commonly done in microscopy, to those older growths of the cell usually known as lignified or woody tissue, in which the original cell has received secondary deposits, and has as a whole been more or less changed in composition and reactions from cellulose.

Cellulose as it occurs in plant structures presents considerable variety in physical properties. Sometimes it is soft, as in the young plant, and again it is quite dense. This fact accounts for the varying results obtained when cellulose is subjected to the action of staining liquids.

The staining of young and soft cellular tissue presents no special difficulties, but when the cellulose increases in density the difficulty is increased; and this is true whether the cellulose is in a nearly pure condition, as in the cotton fibre, or in the modified condition of lignin or woody fibre. Stains which readily attack young cellulose tissue have practically no effect upon it in its maturer form.

Some time ago I had occasion to make a series of tests on the comparative value of several stains in the staining of cellulose and lignin as found in textile and woody fibres; and as the information on this subject in the books is very limited, it was thought that the matter might be of sufficient interest to bring some of the results before the Society.

It is of course important, in the staining of fibres for microscopic examination, that they shall take the stain uniformly. In com-

mercially dyed fabrics this will often be found to have been done very imperfectly. Thus a piece of Turkey red appears in the piece to be well dyed, and practically it is; but when examined microscopically it will be found that the individual fibres have taken the dye very unevenly. This is often the case with fabrics, especially cotton and linen, which have been dyed in the piece; whereas if the fibre is dyed before weaving, as in the gingham, the result on the individual fibres is more uniform.

A mordant is a substance which has an affinity for both organic tissues and coloring matters, and which by virtue of this property is employed in dyeing to fix the color upon the tissue.

The most common mordant in staining microscopic preparations is alum, a solution of which is usually mixed with the stain previous to its application. Other substances, as dilute solutions of organic and mineral acids, are sometimes used under the name of "fixers." Their action is seldom that of a true mordant, their efficiency, when they possess any, being confined to some decomposition of the coloring matter or to some action upon the tissue itself.

In staining animal and vegetable sections some stains require a mordant, while others do not. Thus hæmatoxylin, or the staining principle of logwood, is often used without a mordant, while most of the carmine stains require one.

The staining of tissues may be effected in four ways. First, when the stain has sufficient affinity for the tissue to be retained by it without the intervention of any outside agent. Second, when the stain and mordant are mixed and applied to the tissue in one solution. These two are the simplest and easiest methods of staining. Third, when the tissue is first immersed in the staining liquid and then transferred to some other liquid which shall fix the color upon the tissue. Fourth, when the tissue is first impregnated with the mordant, or fixing agent, and then immersed in the stain. The last method is the one usually followed in commercial dyeing establishments, and is to be recommended in the staining of microscopical preparations which do not readily take the stain.

It is easy to see that, in substances which are difficult to stain, there is less chance of effecting the object when the mordant and stain are both presented to the object at the same time, than when

it is first impregnated with the mordant and then brought into contact with the stain. The tests which I have made, and the specimens which are here for examination, amply prove this. They include a large number of specimens illustrating the action of the different stains upon cotton and linen fabrics, and in some cases upon woody fibres also. Some specimens show the effect of the stains when used alone, while others show the effect of the same stains when used in connection with different mordants. The mounted preparations placed under the several microscopes show the microscopic appearance of some typical specimens of these stained fibres.

Grenacher's Carmine is a solution of carmine in alum, which one authority states will stain cellulose a fine red, but does not stain lignified or suberized tissues. This clearly refers to cellulose as it occurs in soft vegetable tissues, and the same doubtless applies to the staining of cellulose as described in works on the subject. Cotton and linen fibres which were immersed in this stain for twelve hours and washed in water had only a slight reddish tint. The fibres were then immersed in the stain for fifty-four hours with no better result.

Thiersch's Carmine is a solution of carmine with oxalic acid. Cotton fibre was immersed in this stain for eighteen hours and washed. It had a dull rose color, which was very faint when seen in individual fibres as in the mounted preparation.

Borax Carmine.—The result with this stain both upon cotton and linen fibres was about the same as with Grenacher's carmine. Oxalic acid was used as a "fixing" agent.

Logwood and Brazilwood.—In the tests which were made with these dyes I used a tincture obtained by soaking the chips in strong alcohol, and filtering when necessary.

As already stated, hæmatoxylin, or logwood stain, can often be used without a mordant in the staining of vegetable sections, but when applied to cellulose fibres it is almost without action.

A common preparation of hæmatoxylin for staining purposes is its solution with alum. This is claimed to stain both cellulose and lignified tissue, but not suberin. When cotton fibre is immersed in this solution for four hours it is very fairly stained, and when mounted in balsam has a light blue color. If the fibre

is first mordanted and then stained, almost any depth of color can be obtained.

The mordants tried were alum, acetate of alumina, sulphate of copper, and acetate of copper. These were used in strong solutions.

The solution of acetate of alumina is readily prepared by adding a solution of acetate of lead to one of alum (leaving the alum slightly in excess), and filtering.

The fibre was soaked in the mordant for about an hour, the excess squeezed out, and the fibre then immersed in the alcoholic solution of the dye-wood for an hour or longer as the case required.

The uniform staining of the fibre is facilitated by moving it about while in the mordanting and in the staining solutions.

As will be seen from the specimens, there is practically little difference between the results obtained with the different mordants and logwood. Alum and acetate of alumina give a purple shade, while the copper mordants give a decided blue. With brazilwood the fibres mordanted with alum are not so deeply stained as when the other mordants are employed.

Of the four mordants tried the preference must be given to the acetates of alumina and copper. This accords with the general practice in dyeing establishments. The reason is that the acetates are less stable compounds than the sulphates, and consequently yield the bases, alumina and copper oxide, more readily to the fibre.

The specimens of cotton fibre dyed with brazilwood illustrate this very clearly, those mordanted with the acetates being of a much deeper shade than those in which the sulphates were used.

For lignified fibres there is no better stain than logwood, with the previous mordanting of the fibre. With the mordant and stain combined in one solution the result was not satisfactory, some fibres being fairly well stained while others were not stained at all.

The mordants already mentioned were tried on a variety of woody fibres with both logwood and brazilwood, but I submit for your examination only those of spruce and poplar. It will be seen from the specimens and slides that the fibres have taken the stain very uniformly.

Anilin Stains.—Satisfactory results in staining cellulose and

lignified fibres can be obtained by means of the anilin colors. In my experience, however, the staining of lignified fibres is not in all cases as uniform as is desirable.

When applied without a mordant, the fibre is only slightly stained, and a mordant is therefore necessary in order to obtain a stain sufficiently deep and permanent.

In some cases this may be effected by staining first and then mordanting, but, as already stated, it is better in the staining of fibres to reverse this order and apply the mordant first. In this way the staining may be effected in less time and the fibre be more deeply stained.

The method of mordanting the fibre was as follows : It was first immersed in a ten per cent solution of tannic acid for about an hour, the excess squeezed out, then placed in a one per cent solution of stannate of soda for about thirty minutes, transferred to water acidulated with sulphuric acid for a moment, washed in water, and placed in the stain for fifteen to thirty minutes, and finally well washed. The times here given for the action of the different solutions can be shortened in many cases.

A solution of tartar emetic, or tartrate of antimony and potash, was substituted in some experiments for the stannate of soda, but I think the latter is to be preferred for the reason that the tartrate solution soon develops fungous growths.

The list of anilin colors available for staining purposes is quite a long one. I have tried some six or eight of these, but will refer to only four, all of which have given good results and furnish all needed variety in color.

These stains were tried with cotton, linen, and spruce fibres, and the mixed fibre obtained from a sample of filter paper, and the specimens and slides here show the results obtained.

Fuchsin.—This was used in an aqueous solution containing 0.25 gramme in 100 c.c. of water.

I may mention parenthetically that this stain when properly applied is the best material I have found for staining wool fibres so as to bring out distinctly the structure of the scales. A slide containing some of these stained fibres will be found under one of the microscopes.

Hofmann's Violet.—This was used in a strong alcoholic solution. Unmordanted cotton fibre is stained a very light blue,

which when mounted for the microscope appears quite colorless. The fibre, when mordanted in the manner described, takes a deep blue.

Methyl Green—This is a favorite stain, especially for vegetable sections, and it is very effective in double staining. When applied to fibres, whether of pure cellulose or of lignin, it produces a deep green if the fibre has been mordanted before staining, while a light green is produced when the order of stain and mordant is reversed. It was applied in a strong aqueous solution.

Paris Violet.—This is a strong staining medium, readily imparting its color to almost all fibres, but requiring thorough mordanting to render it permanent.

It was used in a concentrated aqueous solution. As will be seen from the specimens, the result is a decided violet, differing in this respect from the bluer shade obtained with Hofmann's violet.

LIST OF ILLUSTRATING SPECIMENS.

Where stain and mordant were applied separately, the former is italicized.

Cotton fibre, stained with Grenacher's carmine.

Linen	"	"	"	"	"
Cotton	"	"	"	Thiersch's	"
"	"	"	"	borax	"
Linen	"	"	"	"	"
Cotton	"	"	"	alum and logwood in one solution.	
"	"	"	"	alum and <i>logwood</i> in separate solutions.	
"	"	"	"	acetate of alumina and <i>logwood</i> .	
"	"	"	"	sulphate of copper and <i>logwood</i> .	
"	"	"	"	acetate of copper and <i>logwood</i> .	
Linen	"	"	"	"	"
Cotton	"	"	"	alum and <i>brazilwood</i> .	
"	"	"	"	acetate of alumina and <i>brazilwood</i> .	
"	"	"	"	sulphate of copper and <i>brazilwood</i> .	
"	"	"	"	acetate of copper and <i>brazilwood</i> .	
Spruce	"	"	"	alum and <i>logwood</i> .	
"	"	"	"	acetate of alumina and <i>logwood</i> .	
"	"	"	"	acetate of copper and <i>logwood</i> .	
Poplar	"	"	"	alum and <i>logwood</i> .	
"	"	"	"	acetate of alumina and <i>logwood</i> .	
"	"	"	"	acetate of copper and <i>logwood</i> .	
Spruce	"	"	"	alum and <i>brazilwood</i> .	
"	"	"	"	acetate of alumina and <i>brazilwood</i> .	
Poplar	"	"	"	alum and <i>brazilwood</i> .	

Poplar fibre, stained with acetate of alumina and <i>brazilwood</i> .									
Cotton	"	"	"	<i>fuchsin</i> and tannic acid and tartar emetic.					
"	"	"	"	tannic acid and stannate of soda and <i>fuchsin</i> .					
Linen	"	"	"	<i>fuchsin</i> and tannic acid and tartar emetic.					
"	"	"	"	tannic acid and stannate of soda and <i>fuchsin</i> .					
Cotton	"	"	"	<i>Hofmann's violet</i> , no mordant.					
"	"	"	"	tannic acid and stannate of soda and <i>Hofmann's violet</i> .					
"	"	"	"	<i>methyl green</i> , no mordant.					
"	"	"	"	<i>methyl green</i> and tannic acid and tartar emetic.					
"	"	"	"	tannic acid and stannate of soda and <i>methyl green</i> .					
Linen	"	"	"	<i>methyl green</i> and tannic acid and tartar emetic.					
"	"	"	"	tannic acid and stannate of soda and <i>methyl green</i> .					
Cotton	"	"	"	tannic acid and tartar emetic and <i>Paris violet</i> .					
"	"	"	"	tannic acid and stannate of soda and <i>Paris violet</i> .					
Linen	"	"	"	"	"	"	"	"	"
Spruce	"	"	"	"	"	"	"	"	and <i>fuchsin</i> .
"	"	"	"	"	"	"	"	"	and <i>methyl green</i> .
"	"	"	"	"	"	"	"	"	and <i>Paris violet</i> .
Fibre of filter paper.	"	"	"	"	"	"	"	"	and <i>fuchsin</i> .
"	"	"	"	"	"	"	"	"	and <i>methyl green</i> .
"	"	"	"	"	"	"	"	"	and <i>Paris violet</i> .

PROCEEDINGS.

MEETING OF APRIL 6TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Forty-six persons present.

A communication was presented from the Secretary of the Scientific Alliance, asking the concurrence of the Society in an application to the postal authorities to reduce the postage on mailable scientific specimens, and also in requesting scientific societies in foreign lands to act in the same matter at the approaching postal union.

The Board of Directors unanimously resolved on such concurrence.

Mr. Stephen Helm addressed the Society on "Marine Life." This address, being introductory to an intended series on this subject, was illustrated by numerous enlarged diagrams and dried specimens.

OBJECTS EXHIBITED.

1. Section of chalcedony : by J. D. HYATT.
 2. Male and female Copepods from Wood's Holl, Mass. : by H. W. CALEF.
 3. Young of *Limulus* from Cold Spring Harbor, N. Y. : by MRS. M. O. LE BRUN.
 4. Hydroid form of *Obelia commisuralis* from Cold Spring Harbor, N. Y. : by MRS. M. O. LE BRUN.
 5. Sertularian from Cold Spring Harbor, N. Y. : by MRS. M. O. LE BRUN.
 6. *Globigerina* from "Challenger Expedition" soundings, 1,450 fathoms : by JAMES WALKER.
 7. Male and female forms of pond life from Crotona Park, N. Y. : by F. W. LEGGETT.
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ANNUAL EXHIBITION, APRIL 17TH, 1894.

The Fifteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New York City, on the evening of April 17th, 1894.

Objects and apparatus, as noted in the programme below, were displayed in the halls of the second floor of the Museum. At 9 o'clock Dr. Edw. G. Love, in the main lecture room, gave an explanation of numerous projections of photomicrographs upon the screen. It was estimated that about two thousand persons were present at the exhibition.

EXHIBITS.

1. Volvox Globator, living ; these hollow vegetable spheres seen in active rotary motion, caused by innumerable cilia arranged upon the surface of the globe : by CHARLES S. SHULTZ.
2. Fossil Coal, section from Bowling-on-the-Clyde, Scotland. From its appearance it is undoubtedly a portion of a Stigmaria plant retaining its original cell structure : by CHARLES S. SHULTZ.
3. Arranged Group of Diatoms forming Pleurosigma Rosette, 130 forms : by E. A. SCHULTZE.
4. Tongue, *Odontophore*, of Snail : by J. D. HYATT.

5. Grappling-hook Spicules of Sponge, *Hyalonema* : by J. D. HYATT.

6. Atacamite (*Chloride of Copper*) : by J. W. METCALF, M.D.

7. Ruby Copper from Morenci, Arizona, shown with an aluminium microscope, weight two pounds. Stage can be lowered to the base to allow use of low-power objectives in searching over large mineral specimens : by PROF. WALLACE GOOLD LEVISON.

8. Circulation of Protoplasm (*Cyclosis*) in the water plant *Nitella* : by H. S. WOODMAN.

9. Section of Human Intestine from a Case of Arsenical Poisoning : by J. A. GOTTLIEB, A.M., M.D.

10. Longitudinal Section of the Cells of the Endosperm of Ivory Nut, *Plytelephas macrocarpa* Ruiz and Pavon, shown with polarized light, magnified 250 diameters : by REV. J. L. ZABRISKIE.

11, 12. Two Slides of Blood of *Amphiuma* stained by different methods. In the *Amphiuma*, as in all amphibia, the blood corpuscles are nucleated and of enormous size compared with those of human blood : by F. D. SKEEL, M.D.

13. Fresh Water Shrimp, *Gammarus pulex*, by polarized light : by WILLIAM WALES.

14. Tooth of Fossil Fish in Coal : by FREDERICK KATO.

15. Eggs of Umbre Moth : by C. H. DENISON.

16. Skin of Sole, by polarized light : by F. COLLINGWOOD.

17. Calamine (zinc silicate) from Franklin Furnace, N. J., by polarized light : by J. W. FRECKELTON.

18. Arranged groups of Diatoms : by GEORGE H. BLAKE.

19. Head of Tapeworm, *Tænia Solium*, showing the Rostellum and Suckers : by L. SCHÖNEY, M.D.

20. *Trichina Spiralis*, encysted in human tissue : by THOMAS S. NEDHAM.

21. Pond Life : by W. J. LLOYD.

22. Six Sections of Serpentine from different localities, shown on automatic revolving stage by polarized light : by JAMES WALKER.

23. Polycistina from Barbadoes Earth, illuminated by parabola : by JAMES WALKER.

24. Section of Bud of Lily : by HORACE W. CALEF.

25. Opal from Australia : by GEORGE E. ASHBY.
26. Tillandsia (*Hanging Moss*) : by F. W. LEGGETT.
27. Young Spiders : by W. D. MACDONALD.
28. Transverse Section of Optic Nerve of Human Infant : by WILLIAM BEUTENMÜLLER.
29. Transverse Section of Stomach of Frog : by WILLIAM BEUTENMÜLLER.
30. Poison of Viperine Snakes : by RAYMOND DITMARS.
31. Vinegar Eels, living : by A. BEUTENMÜLLER.
32. Palm Leaf, transverse section : by ANTHONY WOODWARD, PH.D.
33. Advertisements, Travelling in Olden Time : by ANTHONY WOODWARD, PH.D.
34. Plasmodium of one of the Myxomycetes : by WILLIAM CRAIG.
35. A living Diatom, *Bacillaria paradoxa* : by CAPT. O. H. WILSON.
36. A New Pond Fishing Outfit for catching Pond Life : by CAPT. O. H. WILSON.
- 37-39. Etchings of Steel, showing structure : by P. H. DUDLEY and THOMAS B. BRIGGS.
 37. Manganese Steel for Car Wheels.
 38. A 0.60% Carbon, with 0.18% Silicon, for Steel Rails.
 39. A 0.50% Carbon, with 0.15% Silicon, for Steel Rails.
40. Crystals of Silver precipitated on Copper from the Nitrate : by MICHEL M. LE BRUN.
41. Transverse Section of Yellow Water Lily, *Nuphar advena* : by MARIA O. LE BRUN.
42. Crystals of Cinnabar in Chalcedony (opaque) : by ARTIS H. EHRLMAN.
43. Young Sea Horse, *Hippocampus Hudsonius*, born in the Aquarium, ten days old : by W. E. DAMON.
- 43A. Suction Cups from the Arms of the Devilfish (*Architeuthis princeps*), showing the serrated, saw-like edge with which the animal fastens itself to its prey : by W. E. DAMON.
44. Butterfly's Wing, showing arrangement of Scales. Magnified one hundred times : by WALTER H. MEAD.
45. Circulation of Blood in Tadpole of Newt : by A. D. BALEN.
- 46, 47. Pond Life : by STEPHEN HELM.

48. Mounted Specimen of Larval Sea Urchin, *Arbacia punctulata*, stained with hæmacalcium : by ERNEST V. HUBBARD.

49. Older Larvæ and Ova in Early Segmentation Stages, preserved in Alcohol : by ERNEST V. HUBBARD.

50-53. Microphotographs, selected : by SERENO N. AYRES.

54-58. Animal and Vegetable Fibres, Wool, Silk, Linen, and Cotton : by E. G. LOVE, PH.D.

59-61. Studies of *Utricularia* : by C. L. POLLARD.

59. Mature Plant.

60. Slide showing the modified leaf forming a bladder-like trap for catching minute animals.

61. Slide showing the organs of digestion.

62-63. Anatomy of the Stem of *Polygonum* : by JOHN K. SMALL.

62. Longitudinal radial section of *Polygonum Persicaria*.

63. Transverse section of *Polygonum aviculare*.

64-65. Histological Features of *Büttneria fertilis* : by T. H. KEARNEY, JR.

64. Section of pericarp of the seed.

65. Transverse section of the seed.

66-69. Study of *Nitella* : by A. E. ANDERSON.

66. Growing plant.

67. Slide showing antheridium and archegonium.

68. Slide showing manubrium, capitulum, antheridial filaments, antherozoids, etc.

69. Slide showing oospore and pericarp.

70-71. 1. Formative Stages of the Thallus of *Cladonia mitrula* : by CARLTON C. CURTIS, PH.D.

2. *Phegopteris Phegopteris* : illustration of the differentiation of the elements of the leaf and the optical penetration that may be secured in histological work.

72. Cuprite (Oxide of Copper) : by H. FINCKE.

73. Gold Ore : by H. FINCKE.

74. Arranged Groups of Diatoms : by H. FINCKE.

75. Microphotograph, the Descent from the Cross : by H. FINCKE.

76. Diamond Beetle : by H. FINCKE.

77. Human Retina : by H. FINCKE.

78. *Triceratium Trifoliatum*. Diatom from Lloyd's Neck, L. I. This diatom has never been found except at Wellington, New Zealand : by HEINRICH RIES.

79. *Melosira Granulata*. Diatom Ehr , Ralf's cretaceous clay, from Glen Cove, L. I. : by HEINRICH RIES.

80. Transverse Section of the Head of Embryo Garter Snake, *Eutania Sirtalis* : by LUDWIG RIEDERER.

81. Section of Head of Honey-Bee, *Apis mellifica* : by LUDWIG RIEDERER.

82. Sagittal Section of Abdomen of an Ichneuman-Fly, *Cryptus Samie* : by LUDWIG RIEDERER.

83. Sagittal Section of Abdomen of a Dragon-Fly, *Libellula semifasciata* : by LUDWIG RIEDERER.

84. Microtome, manufactured by Aug. Becker, Göttingen, Germany : by LUDWIG RIEDERER.

85. Selections of Serial Sections : by LUDWIG RIEDERER.

86. Exuviated Cuticle from De Kay's Brown Snake, *Storeria Dekay* ; showing cornea, scales, etc. : by HENRY C. BENNETT.

87. Insect Scales, arranged in form of a Vase of Flowers : by G. S. WOOLMAN.

88. Proboscis of Blow-Fly : by G. S. WOOLMAN.

89. Crystals of Copper : by G. S. WOOLMAN.

90. Head of Mosquito, male : by G. S. WOOLMAN.

91. Saw of the Rose Saw-Fly : by G. S. WOOLMAN.

92. Foot of Spider : by G. S. WOOLMAN.

93. Circulation of Blood in a Frog's Foot : by JOSEPH C. THOMPSON, F.R.M.S.

94. Pond Life : by JOSEPH C. THOMPSON, F.R.M.S.

Alcove A.

Six Photomicrographs, selected, taken by the late Gen. Woodward about twenty years ago : by GEORGE H. BLAKE.

Alcove Q.

1. Tongue of Butterfly : by WILLIAM KRAFFT.

2. Hypopus Muscarum, parasitic on flies : by WILLIAM KRAFFT.

3. Calcareous Corpuscles, from *Cucumaria pentactes*, shown with polarized light : by WILLIAM KRAFFT.

4. Asparagine, shown with polarized light : by WILLIAM KRAFFT.
5. Pond Life, consisting of Hydras, etc.: by G. DUPUY.
6. Collection of Designs : by G. DUPUY.

Alcove R.

1. Spider's Foot, illustrated by an accompanying photograph: by P. LYONS.
2. Specimens to be used for Microscopic Mounting (animal and mineral) : by P. LYONS.
3. Sectioned Specimens; after having been treated and sectioned with microtome; and minerals ground : by E. J. RIEDERER.
4. Specimens under Microscope, polarized light, and also top-light for mineral and naked-eye drawing : by E. J. RIEDERER.
5. Drawings of Microscopic Objects by the use of Zeiss' Camera Lucida : by G. W. KOSMAK.
6. Camera illustrating Process of Photographing Microscopic Objects with Use of the Microscope : by G. W. KOSMAK.
7. Thyroid Gland, illustrated by charts and drawings : by W. W. BOYD, JR.
8. Human Lung, sectioned with Microtome : by E. GOLDBACHER.

Alcove S.

The Frog and the Fern. Two types of animal and plant life, to illustrate the similarities and differences between these two great divisions or kingdoms of animated nature. The gross and minute structure of each will be examined and explained by charts, microscopic preparations and dissections, with special attention to nutritive and respiratory processes, and the general development of both types : by GEORGE WILLIAM KOSMAK.

MEETING OF APRIL 20TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty persons present.

Mrs. Virginia B. Gibbs was elected a Resident Member of the Society.

The Committee on Annual Exhibition presented its report, the report was adopted, and the committee was discharged with thanks.

On motion the thanks of the Society were tendered to those who, although not members of the Society, exhibited specimens and apparatus at the late Annual Exhibition.

On motion the thanks of the Society were tendered President Morris K. Jesup and the members of the Board of Trustees of the American Museum of Natural History for their kindness in granting the use of the halls of the Museum, and to Mr. William Wallace, superintendent of the buildings, and his assistants, for their kind offices on the occasion of the late Annual Exhibition.

Dr. Edw. G. Love read a paper entitled "Notes on the Staining of Cellulose." This paper, published in this number of the JOURNAL, was illustrated by the exhibition of many bottles of stains; by many macroscopic samples of stained fibres (see conclusion of the published article); and by eight slides of mounted stained fibres under microscopes, as noted below.

OBJECTS EXHIBITED.

1. Linen fibre; stained, acetate of alumina and logwood.
2. Linen fibre; stained; mordant, tannic acid and stannate of soda; stains, fuchsin, Paris violet, and methyl green.
3. Cotton fibre; stained, acetate of copper and logwood.
4. Cotton fibre; stained, acetate of alumina and brazilwood.
5. Cotton fibre; stained; mordant, tannic acid and stannate of soda; stains, fuchsin, Paris violet, and methyl green.
6. Cotton fabric, Turkey red.
7. Wool, silk, cotton and linen; mordant, tannic acid and stannate of soda; stains, fuchsin, Paris violet, and methyl green.
8. Poplar fibre; stained, acetate of copper and logwood. Exhibits Nos. 1-8 by EDW. G. LOVE.
9. Living colony of *Megalotrocha*: by JAMES WALKER.
10. Living colony of *Melicerta ringens*: by JAMES WALKER.

Mr. Walker stated that the water and mud supplying the colony of *Melicerta* were collected six weeks since and were placed in glass battery jars. The water of this particular jar was changed after four days. He lately found fifty colonies of *Melicerta* attached to the sides of the jar; but four days previously he could

find none. These specimens built their tubes with remarkable rapidity. Large aquatic worms infested all the colonies, writhing amid the bases of the tubes, and continually startling the rotifers to contraction, as could be seen under the microscope.

MEETING OF MAY 4TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Sixteen persons present.

Mr. James C. Gregory was elected a Resident Member of the Society.

The Recording Secretary read a communication from the Council of the Scientific Alliance requesting the concurrence of the Society in the arrangement of a co-operative course of ten lectures, to be delivered at the American Museum of Natural History or the Cooper Union Building. On motion such concurrence was granted.

The Recording Secretary read a communication from the Citizens Committee of Brooklyn on Entertainment of the American Association for the Advancement of Science, inviting the Society to attend the receptions, meetings, and excursions of the Association. On motion the invitation of the Citizens Committee was accepted with thanks.

Mr. James Walker reported for the Committee on Uniform Cases, Drawers, Trays, and Labels, and the report was accepted and adopted.

OBJECTS EXHIBITED.

1. Rare living form of *Hydra* with rudimentary tentacles : by HENRY C. BENNETT.

2. Living *Plumatella*, developed from statoblast in aquarium : by JAMES WALKER.

3. Living *Fredericella* from Croton water : by A. D. BALEN.

4. Section of Labradorite : by GEORGE E. ASHBY.

From the Society's Cabinet.

5. Sunstone : aventurine feldspar, internal reddish, fire-like reflection from disseminated crystals of hematite or gothite.

6. Aventurine, artificial ; glass mixed with filings of copper.

7. Hypersthene ; silicate of magnesia containing iron.
8. Oölite from India.
9. Oölitic sand from Great Salt Lake.

Mr. Ashby said of his exhibit of Labradorite : "The play of colors, especially remarkable in much Labradorite, indicates, according to Reusch, the existence of a cleavage structure of extreme delicacy, transverse to the median or brachydiagonal section. The play of color appears to be that of thin plates ; yet the linings of what he regards as a cleavage system appear to be of indistinguishable minuteness ; and although the existence of thin plates can hardly be established by means of the microscope, it is proved by their effects in the play of colors, nebulous images within, and the phenomena of inflection or diffraction which result from their regular grouping. This play of colors is independent of the disseminated microscopic crystals of foreign substances which occasion the *aventurine* effect."

MEETING OF MAY 18TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Eighteen persons present.

The Recording Secretary read a communication from the American Geographical Society relative to the Sella collection of mountain photographs now on exhibition at the American Museum of Natural History. The Recording Secretary stated that he had replied to this, and had received tickets of admission which he would distribute to the members. On motion the Recording Secretary was directed to express the thanks of the Society to the American Geographical Society.

The President called the attention of the Society to the proposed meeting of the American Microscopical Society, to be held in Brooklyn three days before the meeting of the American Association for the Advancement of Science. After an address on the subject by Mr. George S. Woolman, and the reading by the Recording Secretary of a communication from the Secretary of the American Microscopical Society to Mr. Woolman asking for information regarding accommodations, on motion the Chair appointed the following committee to consider and report any

possible action on the matter : Dr. Edw. G. Love, Messrs. George S. Woolman and L. Riederer.

OBJECTS EXHIBITED.

1. Mounts, *in toto*, of chick embryos of 36 and 54 hours' incubation : by GEORGE W. KOSMAK.
2. Series of cross-sections of the 54-hour embryo : by GEORGE W. KOSMAK.
3. Insect in amber : by JAMES WALKER.
4. Living embryo leech : by HENRY C. BENNETT.
5. Living *Plumatella* : by A. D. BALEN and FREDERICK KATO.
6. Curious green-colored sand from Kentucky : by F. D. SKEEL.
7. Insect in fossil gum copal from Zanzibar, Africa : by GEORGE E. ASHBY.

Mr. Kosmak explained the method of preparation of his sections of chick embryo.

MEETING OF JUNE 1ST, 1894.

In the absence of the President and the Vice-President, Rev. J. L. Zabriskie was elected Chairman.

Fifteen persons present.

Mr. E. Gerber was elected a Resident Member of the Society.

The Recording Secretary read the report of Mr. George S. Woolman, of the Committee on Entertainment of the American Microscopical Society, stating that the said society would be accommodated at the Polytechnic Institute, Brooklyn. The report was accepted and adopted.

OBJECTS EXHIBITED.

1. Serpentine from Meissen, Saxony, polarized : by HENRY C. BENNETT.
2. Sunstone : by F. D. SKEEL.
3. The common scarlet leaf-hopper, *Diedrocephala coccinia* Först., entire : by J. L. ZABRISKIE.
4. Hairs of sea mouse, *Aphrodite aculeata* : by H. W. CALEF.
5. Pond life : by JAMES WALKER.
6. Living cheese mites : by THOMAS S. NEDHAM.
7. Living *Pectinatella magnifica* : by A. D. BALEN.

MEETING OF JUNE 15TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirteen persons present.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, dated Mobile, Ala., June 7th, 1894, announcing to the Society that he had, in a manner most satisfactory to himself, just succeeded in perfecting the proof that the diatom belongs to the animal kingdom.

OBJECTS EXHIBITED.

1. Section of conglomerate from the drift of Long Island, N. Y.: by JAMES WALKER.
2. The curious parasitic wasp, *Ceratopus* sp.? by J. L. ZABRISKIE.
3. Flowers of *Vincetoxicum acuminatum* with captured mosquitoes: by T. B. BRIGGS.
4. Androconium scales of wing of the butterfly, *Pieris rapæ*: by E. G. LOVE.
5. Circulation in *Nitella*, from Crotona Park, N. Y.: by F. W. LEGGETT.
6. Living *Volvox globator*: by A. D. BALEN.

Objects from the Society's Cabinet.

7. Group of foraminifera.
8. Group of foraminifera and spicules.
9. Group of foraminifera, *Spirolina austriaca*.
10. Foraminifera from the Levant.
11. Section of orbitolite.
12. Section of *Polystomella scrobiculata*.

Mr. Briggs stated that his specimen of *Vincetoxicum* was from the gardens of Mr. Charles A. Dana. The mosquitoes are attracted and held captive by the very viscid nectar of the flowers.

Dr. Love with blackboard drawings explained the situation and structure of the "androconium" scales of the butterfly wing. They are found only on the wing of the male, and are supposed to be scent organs.

Mr. Leggett said that his specimen of *Nitella* was taken from a small pool of exceedingly foul water in Crotona Park, where the plant was growing in astonishing luxuriance.

Mr. Balen stated that his specimens of *Volvox* were also taken from a pool with water so foul that the *Volvox* could not be seen. They appeared to thrive under the circumstances, and many specimens showed that they contained within an astonishing number of young forms.

The Society adjourned to meet on the first Friday of October, 1894.

AN INTRODUCTION TO STRUCTURAL BOTANY. By DUKINFIELD HENRY SCOTT, Jodrell Laboratory, Kew, London. 113 figures. London: Adam & Charles Black, 1894. Pp. 288. Price, \$1.

This is intended to be a first guide to the study of the structure of plants in schools. It treats of three types of phanerogams—the Wallflower, the White Lily, and the Spruce Fir—and seems well adapted to its purpose.

PRACTICAL BOTANY FOR BEGINNERS. By F. O. BOWER, Professor of Botany in the University of Glasgow. 13 figures. New York: Macmillan & Co., 1894. Pp. 275. Price, 90 cents.

An excellent condensed guide to biological laboratory work for beginners, conducting them through the microscopical examination—sectioning and mounting—of many selected types of plants, from the highest to the lowest orders.

A MANUAL OF MICROCHEMICAL ANALYSIS. By PROF. H. BEHRENS, Polytechnic School, Delft, Holland, with an introductory chapter by PROF. JOHN W. JUDD, Royal College of Science, London. 84 figures. New York: Macmillan & Co., 1894. Pp. 246. Price, \$1.50.

The English translation of this work is by the author, Prof. Behrens, and it is devoted mainly to the qualitative microchemical wet methods of the examination of the rock-forming minerals. Part I. contains the general method, and the reactions of sixty-three minerals. Part II. contains the analytical examination of mixed compounds. The work is one of Macmillan's Manuals for Students, under the division of chemistry, and is a late summarization of the labors of most eminent men in this branch of study. To those who are engaged in crystallography and petrography it would seem to be invaluable.

SYSTEMATIC SURVEY OF THE ORGANIC COLORING MATTERS.

By G. SCHULTZ and P. JULIUS. Translated and edited with extensive additions by ARTHUR G. GREEN, London Institute, London. New York: Maxmillan & Co., 1894. Pp. 205. Price, \$5.

This work is devoted to the exposition of the products of coal tar. It states that the average quantity of gas tar worked up per annum by the whole world is 530,000 tons. In three divisions it explains the manufacture and gives the formulæ of the raw products, the intermediate products, and the coloring matters; under this latter division tabulating 454 colors by means of parallel columns under the headings: commercial name, scientific name, empirical formula, constitutional formula, method of preparation, year of discovery, discoverer, patents, literature, behavior with reagents, shade and dyeing properties, method of employment.

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THE CRETACEOUS FORAMINIFERA OF NEW JERSEY.

PART II. ORIGINAL INVESTIGATIONS
AND REMARKS.

BY ANTHONY WOODWARD, PH.D.

(Presented April 6th, 1894.)

After a number of years of close and careful study a vast amount of rough material has been worked over. I have succeeded in identifying twenty-six genera and fifty-nine species of Foraminifera from the cretaceous formation of New Jersey. The material examined was in part kindly sent to me by the late Prof. Geo. H. Cook, State Geologist of New Jersey, and collected by Dr. N. L. Britton; it was also received in part from Wm. E. Chase, of Franklin, N. J., and James Walker, of Brooklyn, N. Y., besides many other sources. I spent two days at Mullica Hill, a beautiful Quaker village, collecting marls from the terebratula, gryphæa beds, and the one just above it. From these beds I identified most of the species mentioned in this paper.

The marls from certain localities are very rich in *Nodosaria*, *Crislettaria*, and *Polymorphina*, especially those from Mullica Hill and the yellow limestone from Timber Creek. My most esteemed friend, the late H. B. Brady, F.R.S., of London, England, aided me greatly by verifying such species as I doubted.

LITUOLIDÆ.

Sub-family TROCHAMMINÆ.

TROCHAMMINA Parker and Jones.

TROCHAMMINA INFLATA Montagu, sp.

Nautilus inflatus Montagu. 1808. Test. Brit. Suppl. 81. pl. xviii. fig. 3.

Rotalina inflata Williamson. 1858. Rec. Foram. Gt. Brit. 50. pl. iv. figs. 93, 94.

Rotalina (Trochammina) inflata Parker and Jones. 1859. Ann. and Mag. Nat. Hist. ser. 3. iv. 347. fig. F.

Trochammina inflata. Carpenter. 1862. Introd. Foram. 141. pl. xi. fig. 5.

Trochammina squamata, var. *inflata* Parker and Jones. 1862. Introd. Foram. Appendix. 310.

Trochammina inflata Brady. 1865. Nat. Hist. Trans. Northd. and Durham. i. 95.

Trochammina inflata (?) Tate and Blake. 1876. Yorkshire Lias. 452. pl. xvii. fig. 18.

Trochammina inflata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 338. pl. xli. fig. 4. a-c.

Trochammina inflata Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 28. pl. D. fig. 31.

“Test free ; trochoid or convex, depressed, rotaliform ; consisting of about three convolutions, the outermost of which is formed of five or six very ventricose segments with deeply excavated septal lines. Inferior face somewhat concave, with sunken umbilicus ; peripheral margin lobulated. Aperture small, arched ; situate on the inferior side of the final segment, close to previous convolution, a little within the periphery. Color pale brown, the small primary segments much darker than the rest.”—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, yellow limestone. Rare.

WEBBINA d'Orbigny.

WEBBINA RUGOSA d'Orbigny.

Webbina rugosa d'Orbigny. 1839. Foram. d. Iles Canaries. 125. pl. i. figs. 16-18.

Webbina rugosa d'Orbigny. 1846. Foram. Foss. Vien. 74. pl. xxi. figs. 11, 12.

Test depressed, elongate, twisted, white, above convex rugose, below complanate, with three pyriform chambers; spinose, round aperture, peristome elevated, enlarged.

Locality. Timber Creek, in the yellow limestone. Rare. Also in the teredo bed. Rare.

TEXTULARIDÆ.

Sub-family TEXTULARINÆ.

TEXTULARIA Defrance.

TEXTULARIA AGGLUTINANS d'Orbigny.

Textularia agglutinans d'Orbigny. 1839. Foram. Cuba 144. pl. i. figs. 17, 18, 32-34.

Textularia agglutinans Seguenza. 1862. Atti dell' Accad. Gisenia. ser. 2. xviii. 112. pl. ii. fig. 4.

Plecanium sturi Karrer. 1864. Sitzungsab. d. K. Ak. Wiss. Wien. i. 704. pl. i. fig. 1.

Textularia agglutinans Parker and Jones. 1865. Phil. Trans. clv. 369. pl. xv. fig. 21.

Plecanium agglutinans Reuss. 1869. Sitzungsab. d. K. Ak. Wiss. Wien. lix. 452. pl. i. figs. 1, 2.

Textularia agglutinans G. M. Dawson. 1875. Report Geol. Resources 49th Parallel, British N. A. Boundary Comm. 79.

Textularia agglutinans Moebius. 1880. Foram. von Mauritius. 93. pl. ix. figs. 1-8.

Textularia agglutinans Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 363. pl. xliii. figs. 1-3. vars. figs. 4, 12.

Textularia agglutinans Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 167. pl. iii. figs. 6, 7.

Textularia agglutinans Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.

Test elongate, conical, rugose, agglutinous (from grains of sand), white, laterally convex, posteriorly cuneate, segments large, the last convex, aperture semi-lunate.

Locality. Timber Creek, in the yellow limestone. Rare.

TEXTULARIA CARINATA d'Orbigny.

Textularia carinata d'Orbigny. 1826. Ann. Sci. Nat. vii. 263. No. 23.

Textularia carinata d'Orbigny. 1846. Foram. Foss. Vien. 247. pl. xiv. figs. 32-34.

Textularia lacera Reuss. 1851. Zeitschr. d. deutsch. geol. Gesell. iii. 84. pl. vi. figs. 52, 53.

Textularia attenuata Reuss. 1851. Zeitschr. d. deutsch. geol. Gesell. iii. 84. pl. vi. fig. 54.

Textularia carinata, and *T. carinata*, var. *attenuata* Reuss. 1870. Sitzungsab. d. K. Ak. Wiss. Wien. lxii. 489. No. 1. Schlicht. 1870. Foram. Pietzpuhl. pl. xxxiii. figs. 1-4, 8, 9.

Textularia carinata Hantken. 1875. Mitth. Jahrb. d. k. ung. geol. Anst. iv. 66. pl. vii. fig. 8.

Textularia carinata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 360. pl. xlii. figs. 15, 16.

Textularia carinata Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 30. pl. C fig. 11.

Test cuneiform, lingulate, convex. punctate, anteriorly dilate, truncate, posteriorly obtuse acuminate, laterally carinate, acute, lamellose; foramina narrow, oblique, arcuate, marginate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare.

TEXTULARIA GRAMEN d'Orbigny.

Textularia gramen d'Orbigny. 1846. Foram. Foss. Vien. 248. pl. xv. figs. 4, 6.

Textularia gramen Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 365. pl. xliii. figs. 9, 10.

Test ovate-lingulate, compressed, punctate, anteriorly dilate, rotund, posteriorly obtuse, laterally angular, subcarinate; with wide chambers, obliquely transverse, arcuate, somewhat convex.

Locality. Timber Creek, in the yellow limestone. Not common.

TEXTULARIA TURRIS d'Orbigny.

Textularia turris d'Orbigny. 1840. Mém. Soc. géol. France. iv. 46. pl. iv. figs. 27, 28.

Textularia turris Parker and Jones. 1853. Ann. and Mag. Nat. Hist. ser. 3. xi. 97.

Textularia turris Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 366. pl. xlv. figs. 4, 5.

Textularia turris Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 167. pl. iii. fig. 8.

Textularia turris (?) Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.

Textularia turris Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 30. pl. C. figs. 9, 10.

Test elongate, conical, turriculate, rugose, non-compressed, posteriorly acuminate, anteriorly truncate; chambers complanate.

Locality. Timber Creek, in the yellow limestone and gryphæa bed. Not abundant.

TEXTULARIA SAGITTULA Defrance.

"*Polymorphum sagittula*" Soldani. 1791. Testaceographia. i. 120. pl. cxxxiii. fig. T.

Textularia sagittula Defrance. 1824. Dict. Sci. Not. xxxii. 177; liii. 344; Atlas Conch. pl. xiii. fig. 5.

Textularia sagittula Blainville. 1825. Malacologie. 370. pl. v. fig. 5.

Textularia sagittula d'Orbigny. 1826. Ann. Sci. Nat. vii. 263. No. 20.

Textularia saulcyana d'Orbigny. 1839. Foram. Cuba. 137. pl. i. figs. 21, 22.

Textularia cuneiformis d'Orbigny. 1839. Foram. Cuba. 138. pl. i. figs. 37, 38.

Textularia nussdorffensis d'Orbigny. 1846. Foram. Foss. Vien. 243. pl. xiv. figs. 17-19.

Textularia bronniiana d'Orbigny. 1846. Foram. Foss. Vien. 244. pl. xiv. figs. 20-22.

Textularia deperdita d'Orbigny. 1846. Foram. Foss. Vien. 244. pl. xiv. figs. 23-25.

Textularia praelonga Czjzek. 1847. Haidinger's Naturw. Abhandl. ii. 149. pl. xiii. figs. 28-30.

Textularia acuta Reuss. 1849. Denkschr. d. K. Akad. Wiss. Wien. i. 381. pl. xlix. fig. 1.

Textularia cuneiformis Williamson. 1858. Rec. Foram. Gt. Br. 75. pl. vi. figs. 158, 159.

Textularia agglutinans, var. *sagittula* Parker and Jones. 1865. Phil. Trans. clv. 369 pl. xvii. fig. 77. a, b.

Textularia sagittula Brady. 1884. Report on Foram H. M. S. Challenger. Zool. ix. 361. pl. xlii. figs. 17, 18.

Test elongate, somewhat compressed, very rugose, posteriorly acuminate-carinate, anteriorly subcylindrical-truncate; with narrow chambers, arcuate, limbate above, aperture linear.

Locality. New Egypt, in the green marl. Rare. Timber Creek, in the gryphæa bed. Quite rare.

SPIROPLECTA Ehrenberg.

SPIROPLECTA AMERICANA Ehrenberg.

Spiroplecta americana Ehrenberg. 1854. Mikrogeologie. pl. xxxii. I. figs. 13, 14; II. fig. 25.

Spiroplecta americana Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 376. pl. xlv. fig. 24. a, b.

Spiroplecta americana Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 168 pl. iii. fig. 9.

Spiroplecta americana Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 31. pl. C. figs. 12, 13, 14.

"The test is usually much compressed, and widens rapidly towards the distal end; the lateral edges are thin and slightly lobulated, the chambers somewhat inflated, and the septal lines correspondingly depressed on the exterior; the walls are thin and smooth."—Brady, loc. cit.

Locality. Timber Creek, in the gryphæa bed. Rare.

GAUDRYINA d'Orbigny.

GAUDRYINA PUPOIDES d'Orbigny.

Gaudryina pupoides d'Orbigny. 1840. Mém. Soc. géol. France. iv. 44. pl. iv. figs. 22-24.

Gaudryina pupoides d'Orbigny. 1846. Foram. Foss. Vien. 197. pl. xxi. figs. 34-36.

Gaudryina subglabra Gümbel. 1868. Abh. d. K. bayer. Akad. Wiss. II. cl. x. 602. pl. i. fig. 4.

Gaudryina pupoides Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 378. pl. xlv. figs. 1-4.

Gaudryina pupoides Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 168. pl. iii. fig. 10.

Gaudryina pupoides Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 31. pl. C. figs. 15, 16.

Test elongated, rugose, (young) rotund, (adult) compressed ; spire obtuse ; chambers convex, (young) narrow, transversely oblong, (adult) globular.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare.

VERNEUILINA d'Orbigny.

VERNEUILINA TRIQUETRA Münster, sp.

Textularia triquetra Münster. 1838 (in Römer's paper). Neues Jahrb. für Minn. etc. 384. pl. iii. fig. 19.

Textularia triquetra Reuss. 1845. Verstein. Böhm. Kreid. pt. 1. 39. pl. xiii. fig. 77.

Textularia atlantica Bailey. 1851. Smithsonian Contrib. ii. art. 3. 12. figs. 38-42.

Textularia (Verneuilina) triquetra Parker and Jones. 1863. Ann. and Mag. Nat. Hist. ser. 3. xi. 92.

Verneuilina triquetra Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 383. pl. xlvii. figs. 18-20.

Test carinate, acutely triangular with a curved lateral side (or face) in the centre, so that a cross section presents the appearance of a triangle, with somewhat concave sides. On every side seven to eight very low, somewhat rough chambers, whose sutures are slightly elevated, the uppermost chamber somewhat arched ; aperture a slit on the inner side of the last chamber, parallel to a side face of the pyramid.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Very abundant. Timber Creek, in the gryphæa bed. Abundant.

TRITAXIA Reuss.

TRITAXIA TRICARINATA Reuss.

Textularia tricarinata Reuss. 1845. Verstein. Böhm. Kreid. i. 39. pl. viii. fig. 60.

Verneuilina dubia Reuss. 1850. Haidinger's Naturw. Abhandl. iv. 40. pl. iv. fig. 3.

Tritaxia tricarinata Reuss. 1860. Sitzungsab. d. K. Ak. Wiss. Wien. xl. 228. pl. xii. figs. 1, 2.

Tritaxia tricarinata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 389. pl. xlix. figs. 8, 9.

Test very rough, elongate elliptical, triangular, tricarinate, on either side attenuate, walls somewhat concave, sutures obsolete, aperture small, subelliptical.

Locality. Timber Creek, in the yellow limestone. Quite rare.

CLAVULINA d'Orbigny.

CLAVULINA COMMUNIS d'Orbigny.

Clavulina communis d'Orbigny. 1826. Ann. Sci. Nat. vii. 268. No. 4.

Clavulina communis d'Orbigny. 1846. Foram. Foss. Vien. 196. pl. xii. figs. 1, 2.

Verneuilina communis Jones and Parker. 1860. Quart. Journ. Geol. Soc. xvi. 303. No. 82.

Clavulina communis Fischer. 1870. Actes Soc. Linn. Bordeaux. xxvii. 393. No. 33.

Verneuilina communis Van den Broeck. 1876. Ann. Soc. Belg. Micr. ii. 136. pl. iii. fig. 14.

Clavulina communis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 394. pl. xlviii. figs. 1-13.

Test elongate, clavate, rugose, cylindrical anteriorly, posteriorly inflated, obtuse, convex chambers, terminal one anteriorly subacuminate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Timber Creek, teredo bed. Abundant.

Sub-Family BULIMINÆ.

BULIMINA d'Orbigny.

BULIMINA PUPOIDES d'Orbigny.

Bulimina pupoides d'Orbigny. 1846. Foram. Foss. Vien. 185. pl. xi. figs. 11, 12.

Bulimina pupoides Williamson. 1858. Rec. Foram. Gt. Br. 62. pl. v. figs. 124, 125.

Bulimina tortilis Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 338. pl. viii. fig. 3.

Bulimina presli, var. *pupoides* Parker and Jones. 1862. Introd. Foram. Appendix. 311.

Bulimina pupoides Terrigi. 1880. Atti dell' Accad. Pont. xxxiii. 193. pl. ii. figs. 30-34.

Bulimina pupoides Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 400, 401. pl. l. fig. 15. a, b.

Bulimina pupoides Woodward and Thomas. 1885. 13th Ann. Report Geol. Nat. Hist. Survey Minn. 169. pl. iii. fig. 11.

Bulimina pupoides Tyrrell. 1890. Trans. Roy. Soc. Can. 114.

Bulimina pupoides Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 32. pl. C. figs. 20-24.

Test oblong; obtuse, especially at the inferior lateral surface; composed of numerous segments, arranged in an indistinct spiral, and exhibiting a tendency to form three oblique vertical rows; segments remarkably ventricose and prominent; the anterior one usually more oblong than the rest, from its anterior part not being embraced, as all the preceding ones, by the next segment. Septal plane convex; semilunar. Septal orifice single, placed near the umbilical border of the septal plane, and usually characterized by a curious obliquity at its part, owing to the two lips of the orifice not meeting at their umbilical extremities, but passing one behind the other.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Fragments only.

BULIMINA PYRULA d'Orbigny.

Bulimina caudigera d'Orbigny. 1826. Ann. Sci. Nat. vii. 270. No. 16; Modèle No. 68.

Bulimina ovula d'Orbigny. 1839. Foram. Amér. Mérid. 51. pl. i. figs. 10, 11.

Bulimina pyrula d'Orbigny. 1846. Foram. Foss. Vien. 184. pl. xi. figs. 9, 10.

Bulimina auriculata Bailey. 1851. Smithsonian Contrib. ii. Art. 3. 12. figs. 25-27.

Bulimina turgida Id. Ibid. 12. figs. 28-31.

Guttulina prunella Costa. 1856. Atti dell' Accad. Pont. vii. 274. pl. xiii. figs. 32, 33, 37, 38.

Guttulina mutabilis Id. Ibid. 275. pl. xviii. figs. 1-3.

Bulimina auriculata Dawson. 1859. Canad. Nat. iv. 31. fig. 22.

Bulimina auriculata Id. 1860. Can. Nat. and Geol. v. 190.

Bulimina presli, var. *pyrula* Parker and Jones. 1865. Phil. Trans. clv. 372. pl. xv. figs. 8, 9.

Bulimina pyrula Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 399. pl. l. figs. 7-10.

Bulimina pyrula Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 114.

Test ovate, anteriorly and posteriorly acuminate, smooth, short spire, obtuse; with three narrow convolutions; with three somewhat convex segments.

Locality. Timber Creek, teredo bed. Rare.

PLEUROS TOMELLA Reuss.

PLEUROS TOMELLA SUBNODOSA Reuss.

Nodosaria nodosa (pars) Reuss. 1845. Verstein. Böhm. Kreid. pt. 1. 28. pl. xiii. fig. 22 (*fide* Reuss).

Dentalina subnodosa (pars) Id. 1850. Haidinger's Naturw. Abhandl. iv. 24. pl. i. fig. 9 (*fide* Reuss).

Pleurostomella subnodosa Id. 1860. Sitzungsab. d. K. Ak. Wiss. Wien. xl. 204. pl. viii. fig. 2. a, b.

Pleurostomella subnodosa Marsson. 1878. Mittheil. Naturw. Verein. Neu-Vorpom. u. Rügen. x. 133.

Pleurostomella subnodosa Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 412. pl. lii. figs. 12, 13.

Test elongated, nearly straight; chambers quite regularly increasing, slightly convex, the last one the largest, convex, shortly acute; the first chamber smallest, rather obtuse; aperture naked.

Locality. Timber Creek, gryphæa bed. Rare.

BOLIVINA d'Orbigny.

BOLIVINA PUNCTATA d'Orbigny.

Bolivina punctata d'Orbigny. 1839. Foram. Amér. Mérid. 61. pl. viii. figs. 10-12.

Bolivina antiqua d'Orbigny. 1846. Foram. Foss. Vien. 240. pl. xiv. figs. 11-13.

- Grammostomum polystigma* Ehrenberg. 1854. Mikrogeologie. pl. xix. fig. 84.
- Grammostomum caloglossa* Ehrenberg. 1854. Mikrogeologie. pl. xxv. figs. 17, 18.
- Bolivina punctata* Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 468. pl. xlviii. fig. 9. a, b.
- Bulimina presli*, var. (*Bolivina*) *punctata* Parker and Jones. 1865. Phil. Trans. clv. 376. pl. xviii. fig. 74.
- Bolivina elongata* Hantken. 1875. Mittheil. Jahrb. d. K. ung. geol. Anstalt. iv. 65. pl. vii. fig. 14.
- Bolivina antiqua* Terrigi. 1880. Atti dell' Accad. Pont. xxxiii. 196. pl. ii. fig. 40.
- Bolivina punctata* Moebius. 1880. Foram. von Mauritius. 94. pl. ix. figs. 9, 10.
- Bulimina* (*Bolivina*) *punctata* Goës. 1882. Kongl. Sv. Vet. Akad. xxix. 69. pl. iv. figs. 114-126.
- Bolivina punctata* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 417. pl. lii. figs. 18, 19.
- Bolivina punctata* Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 169. pl. iii. fig. 12.
- Bolivina punctata* Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 34. pl. C. figs. 27, 28.

Test elongated, compressed, conical, obtuse anteriorly, acuminate posteriorly, white, punctate, sub-carinate on sides; with numerous oblique undulate segments, the last obtuse; aperture simple.

Locality. Lower marl bed, light gray, sandy marl at Bruere's pits, Crosswick's Creek. Rare.

LAGENIDÆ.

Sub-family LAGENINÆ.

LAGENA Walker and Boys.

LAGENA GLOBOSA Montagu, sp.

- "*Serpula* (*Lagena*) *laevis globosa*" Walker and Boys. 1784. Test. Min. 3. pl. i. fig. 8.
- "*Ossicula madreporaria*" Soldani. 1795. Testaceographia. i. pt. 3. 245. pl. clxxii. figs. B, C, etc.

- Vermiculum globosum* Montagu. 1803. Test Brit. 523.
- Oolina inornata* d'Orbigny. 1839. Foram. Amér. Mérid. 21. pl. v. fig. 13.
- Oolina simplex* Reuss. 1851. Haidinger's Naturw. Abhandl. iv. 22. pl. i. fig. 2.
- Miliola sphaeroides* Ehrenberg. 1854. Mikrogeologie. pl. xxxiii. fig. 1.
- Cenchradius oliva* Ehrenberg. 1854. Mikrogeologie. pl. xxiv. figs. 3, 4.
- Phialina oviformis* Costa. 1856. Atti dell' Accad. Pont. vii. 123. pl. xi. figs. 8, 9.
- Fissurina obtusa* Egger. 1857. Neues Jahrb. für Min. etc. 270. pl. v. figs. 16-19.
- Entosolenia globosa* Parker and Jones. 1857. Ann. and Mag. Nat. Hist. ser. 2. xix. 278. pl. xi. figs. 25-29.
- Entosolenia globosa* Williamson. 1858. Rec. Foram. Gt. Br. 8. pl. i. figs. 15, 16.
- Fissurina solida* Seguenza. 1862. Foram. Monotal. Mess. 56. pl. i. fig. 42.
- Entosolenia globosa* Dawson. 1859. Can. Nat. and Geol. iv. 28. figs. 4, 5.
- Entosolenia globosa* Dawson. 1862. Proc. Portland Soc. Nat. Hist. i. 83.
- Fissurina rugosula* Seguenza. 1862. Foram. Monotal. Mess. 56. pl. i. fig. 43.
- Lagena sulcata*, var. (*Entosolenia*) *globosa* Parker and Jones. 1865. Phil. Trans. clv. 348. pl. xiii. fig. 37; pl. xvi. fig. 10.
- Lagena globosa* Jones, Parker, and Brady. 1866. Monograph of the Foram. of the Crag. 32. pl. i. fig. 32.
- Cenchradius aargovense* Kübler. 1870. Foram. Schweiz. Jura. 13. pl. ii. I. fig. 2.
- Lagena parkinsoni* Kübler. 1870. Foram. Schweiz. Jura. 17. pl. ii. III. fig. 1.
- Lagena minutissima* Kübler. 1870. Foram. Schweiz. Jura. 19, 21. pl. ii. IV. fig. 1.
- Lagenulina globosa* Terquem. 1876. Anim. sur la Plage de Dunkerque. fasc. 2. 67. pl. vii. figs. 3, 4.
- Lagena globosa* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 452. pl. lvi. figs. 1, 2, 3.

Test ovato-globose, sometimes projecting slightly at the apex ; smooth, and without surface-marking. Tube entosolenian. Walls thin and hyaline.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

Sub-family NODOSARINÆ.

NODOSARIA Lamarck.

NODOSARIA (D.) COMMUNIS d'Orbigny.

Nodosaria (Dentalina) communis (?) d'Orbigny. 1826. Ann. Sci. Nat. vii. 254. No. 35.

Dentalina communis d'Orbigny. 1840. Mém. Soc. géol. France, iv. 13. pl. i. fig. 4.

Nodosaria linearis Römer. 1842. Verst. Nordd. Kreidegeb. 95. pl. xv. fig. 5.

Nodosaria communis Reuss. 1845. Verstein. Böhm. Kreid. pt. i. 28. pl. xii. fig. 21.

Nodosaria legumen Id. Ibid. 28. pl. xiii. figs. 23, 24.

Dentalina inornata d'Orbigny. 1846. Foram. Foss. Vien. 44. pl. i. figs. 50, 51.

Dentalina badensis Id. Ibid. 44. figs. 48, 49.

Dentalina ferstliana Czjzek. 1847. Haidinger's Naturw. Abhandl. ii. 140. pl. xii. figs. 10-13.

Dentalina intermedia Corn. 1848. Nouv. Foss. Microsc. Cret. ; Mém. Soc. géol. France. ser. 2. iii. 251. pl. i. fig. 20.

Dentalina gracilis Alth. 1849. Umgeb. Lemb. ; Haidinger's Naturw. Abhandl. iii. (2) 269. pl. xiii. fig. 27.

Dentalina mutabilis Bailey. 1850. Smithsonian Contrib. ii. Art. 3. 10. fig. 7.

Marginulina ensis Reuss. 1851. Haid. Nat. Abhandl. iv. p. ii. figs. 16-18.

Dentalina haueri Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. xii. 81. pl. iii. fig. 12.

Dentalina orbignyana Id. Ibid. pl. iii. figs. 1-3.

Dentalina subarcuata Williamson. 1858. Rec. Foram. Gt. Brit. 18. pl. ii. figs. 40, 41.

Dentalina torta Terquem. 1858. Foram. du Lias. 1^{re} mém. 599. pl. ii. fig. 6.

- Dentalina vetusta* Terquem. Ibid. 598. pl. ii. 4.
Dentalina legumen Reuss. 1860. Sitzungsab. d. K. Akad. Wiss. Wien. xl. 187. pl. iii. fig. 5.
Dentalina intermedia Id. Ibid. 186. pl. ii. fig. 8.
Dentalina communis Id. Ibid. 186.
Dentalina colligata Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 334. pl. vii. fig. 4.
Dentalina deflexa Reuss. 1862. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 43. pl. ii. fig. 19.
Dentalina inornata Id. 1863. Ibid. xlviii. 45. pl. ii. fig. 18.
Dentalina boettcheri Id. Ibid. 44. pl. ii. fig. 17.
Dentalina æqualis Karrer. 1865. Foram. Grünsandstein. N. Zeeland; Novara Reise. geol. ii. 74. pl. xvi. fig. 1.
Dentalina communis Jones, Parker, and Brady. 1866. Monograph of the Foram. of the Crag. 58. pl. i. fig. 13-18, 20; pl. iv. fig. 10.
Margulinella ensis Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 335.
Nodosaria neugeboreni Schwager. 1866. Novara Exped. geol. ii. 232. pl. vi. fig. 67.
Nodosaria gracilescens Id. Ibid. 234. pl. vi. fig. 70.
Dentalina intorta Terquem. 1870. Foram. du Syst. Oolith. 3^{ième} mém. 262. pl. xxvii. figs. 26-34.
Dentalina budensis Hantken. 1875. Mittheil. Jahrb. d. K. ung. geol. Anstalt. iv. 34. pl. iii. fig. 12.
Nodosaria (D.) communis Brady. 1884. Report on Foram. H. M. S. Challenger Zool. ix. 504. pl. lxii figs. 19-22.

Test elongated, arched, smooth; posteriorly acuminate, caudate; numerous chambers, oblique, last very convex, acuminate, first convex; sutures subcomplanate; very small aperture, radiate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Not abundant. New Egypt, green marl. Fragments. Lower marl bed, gray sandy marl at Bruere's pits, Crosswick's Creek. Fragments. Timber Creek, in the yellow limestone. Fragments. Teredo bed. Quite abundant. Gryphæa bed. Not rare.

NODOSARIA (D.) FILIFORMIS d'Orbigny.

- "*Orthoceratia filiformia aut capillaria*" Soldani. 1798. Testaceographia. ii. 35. pl. x. fig. e.
- Nodosaria filiformis* d'Orbigny. 1826. Ann. Sci. Nat. vii. 253. No. 14.
- Dentalina acutissima* d'Orbigny. 1839. Foram. Amér. Mérid. 23. pl. iii. fig. 15.
- Dentalina acuta* Id. Ibid. fig. 16.
- Dentalina gracilis* Id. 1840. Mém. Soc. géol. France. iv. 14. pl. i. fig. 5.
- Dentalina elegans* Id. 1846. Foram. Foss. Vien. 45. pl. i. figs. 52-56.
- Dentalina reussi* Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. Wien. xii. 85. pl. iii. figs. 6, 7.
- Dentalina prælonga* Costa. 1856. Atti dell' Accad. Pont. vii. 163. pl. xii. fig. 21.
- Dentalina vetustissima* Terquem. 1858. Foram. du Lias. 1^{ière} mém. 600. pl. ii. fig. 8.
- Dentalina baccata* Id. Ibid. 601. pl. ii. fig. 9.
- Dentalina pseudomonile* Id. Ibid. 606. pl. ii. fig. 18.
- Dentalina gracilis* Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 334.
- Nodosaria elegans* Schwager. 1866. Novara Exped. géol. Theil ii. 233. pl. vi. fig. 68.
- Dentalina filiformis* Parker, Jones, and Brady. 1871. Ann. and Mag. Nat. Hist. ser. 4. viii. 156. pl. ix. fig. 48.
- Nodosaria (D.) filiformis* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 500. pl. lxiii. figs. 3-5.

Test elongate, arcuate, smooth, shining white, anteriorly obtuse, posteriorly acuminate, very acute, with numerous chambers, laterally semi-distinct; aperture round simple.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Fragments only. Teredo bed. Rare.

NODOSARIA OBLIQUA Linné, sp.

- "*Orthoceras minimum*," etc. Gaultieri. 1742. Index Test. pl. xix. fig. N.

- Nautilus obliquus* Linné. 1767. Syst. Nat. 12th ed. 1163. 281 ;
1788. Ibid. 13th (Gmelin's) ed. 3372. No. 14.
- Nautilus jugosus* Montagu. 1803. Test. Brit. 198 pl. xiv.
fig. 4.
- Orthocera obliqua* Lamarck. 1822. Anim. sans Vert. vii. 594.
No. 4.
- Nodosaria sulcata* Nilsson. 1827. Petrif. Suec. 8. pl. ix. fig. 19.
- Nodosaria elegans* Roemer. 1838. Neues. Jahrb. für Min. etc.
382. pl. iii. fig. 1.
- Dentalina bifurcata* Reuss. 1849. Denkschr. d. K. Akad. Wiss.
Wien. i. 367. pl. xlv. fig. 10.
- Dentalina primæva* d'Orbigny. 1850. Prod. Paléont. i. 242.
No. 260.
- Dentalina kingii* Jones. 1850. King's Monogr. Permian Foss.
17. pl. vi. figs. 2, 3.
- Dentalina steenstrupi* Reuss. 1855. Zeitschr. d. deutsch. geol.
Gesellsch. vii. 268. pl. viii. fig. 14, a.
- Dentalina sulcata* Id. Ibid. 269. pl. viii. fig. 14, b.
- Dentalina baltica* Id. Ibid. 269. pl. viii. fig. 15.
- Dentalina bifurcata* Costa. 1856. Atti dell' Accad. Pont. vii.
162. pl. xii. fig. 27.
- Nodosaria mutabilis* Id. Ibid. 150. pl. xiii. fig. 1.
- Nodosaria siphunculoides* Costa. 1857. Mém. Accad. Sci. Nap.
ii. 135. pl. i. fig. 27.
- Nodosaria (Dentalina) obliqua* Parker and Jones. 1859. Ann.
and Mag. Nat. Hist. ser. 3. iii. 482.
- Dentalina pulchra* Gabb. 1860. Journ. Acad. Nat. Sci. ser. 2.
iv. 402, 403. pl. lxix. figs. 40, 41.
- Dentalina steenstrupi* Reuss. 1861. Sitzungsab. d. K. Akad. d.
Wiss. xlv. 326.
- Dentalina confluentis* Reuss. Id. Ibid. 335. pl. vii. fig. 5.
- Nodosaria siphunculoides* Costa. 1857. Foram. Foss. Marne
Terziar Messina. 9. pl. i. fig. 27.
- Dentalina lineata* Reuss. 1864. Sitzungsab. d. K. Akad. d. Wiss.
l. 22. pl. iv. fig. 11.
- Dentalina schwarzi* Karrer. 1864. Sitzungsab. d. K. Akad. d.
Wiss. l. 15. pl. i. fig. 5.
- Dentalina obliqua* Jones, Parker, and Brady. 1866. Monograph
of the Foram. of the Crag. 54. pl. i. fig. 9.

Nodosaria obliqua Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 513. pl. lxiv. figs. 20-22.

Nodosaria obliqua Meyer. 1886. Bull. Geol. Survey Ala. 85. pl. i. fig. 31.

Test elongated, arcuate, tapering; composed of numerous (six to fifteen) chambers, which are subcylindrical and more or less ventricose, with the septal lines generally constricted, and the surface covered with riblets, varying in number and size in different specimens.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Very common. Timber Creek, teredo bed. Not abundant. Near Harrisonville, middle bed, associated with echinoderms. Common.

This is the species that Gabb speaks of finding, and described as a new species *Dentalina pulchra*, from the marl near Mullica Hill. Also *N. sulcata* of Nilsson, who H. v. Credner mentions in Die Kreide von New Jersey d. d. geol. Ges. xiii. 1870, as occurring common in the bryozoan bed at Brownville and Turtle Hill.

NODOSARIA RADICULA Linné, sp.

"*Cornu Hammonis erectum*" Plancus. 1739. Conch. Min. 14. pl. i. fig. 5.

Nautilus radicula Linné. 1767. Syst. Nat. 12th ed. 1164. 285; 1788. Ibid. 13th (Gmelin's) ed. i. pt. 6. 3373. No. 18.

Nautilus radicula Montagu. 1803. Test. Brit. 197. pl. vi. fig. 4.

Nodosaria radicula d'Orbigny. 1826. Ann Sci. Nat. vii. 252. No. 3; Modèle No. 1.

Nodosaria geinitziana Neugeboren. 1852. Verhandl. u. Mitth. siebenb. Vereins f. Nat. iii. 37. pl. i. fig. 1.

Nodosaria glandulinoides Id. Ibid. 37. pl. i. fig. 2.

Nodosaria inconstans Id. Ibid. 38. pl. i. figs. 6, 7.

Glandulina tenuis Bornemann. 1854. Lias-formation. 31. pl. ii. fig. 3. a, b.

Glandulina major Id. Ibid. 31. pl. ii. fig. 4. a, b.

Nodosaria geinitzi Reuss. 1854. Jahresb. d. Wetterauer Gesellschaft. 1851-53. 77. fig. 12.

Glandulina elegans Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. Wien. 69. pl. i. fig. 5.

- Glandulina reussi* Id. Ibid. 69. pl. i. fig. 6.
Nodosaria beyrichi Id. Ibid. 72. pl. i. figs. 7-9.
Nodosaria incerta Id. Ibid. 72. pl. i. figs. 10, 11.
Nodosaria radícula Jones and Parker. 1860. Quart. Journ. Geol. Soc. xvi. 453. figs. 1-5 (Triassic).
Nodosaria geinitzi Richter. 1855. Zeitschr. d. deutsch. Geol. Gesellsch. vii. 532. pl. xxvi. fig. 26.
Nodosaria kirhyi Richter. 1861. Geinitz's Dyas. 121. pl. xx. fig. 30.
Glandulina conica Terquem. 1862. Foram. du Lias. 2^{ième} mém. 435. pl. v. fig. 10. a, b.
Nodosaria jonesi Reuss. 1862. Sitzungsab. d. K. Akad. Wiss. Wien. xvi. 89. pl. xii. fig. 6.
Nodosaria claviformis Terquem. 1866. Foram. du Lias. 6^{ième} mém. 447. pl. xix. figs. 17, 18.
Nodosaria radícula Brady. 1867. Proc. Somerset Arch. and Nat. Hist. Soc. xiii. 106. pl. i. fig. 4.
Nodosaria conferta Schmid. 1867. Neues Jahrb. für Min. Jahrg. 1857. 585. pl. vi. fig. 49.
Nodosaria radícula Brady. 1876. Pal. Soc. xxx. 124. pl. x. figs. 6-16.
Nodosaria radícula Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 495. pl. lxi. figs. 28-31.

Test cylindrical, tapering, composed of several subglobose segments united in a straight line. Surface smooth more or less. A good typical specimen of *Nodosaria radícula* has four or more segments, rarely as many as eight; the segments are subglobular in form, regularly but only slightly increasing in size, from the earliest to the last formed, and quite symmetrically joined end to end.

Locality. Timber Creek, in the yellow limestone. Rare.

NODOSARIA RAPHANUS Linné, sp.

- "*Cornu Hammonis erectum striatum*" Plancus. 1739. Conch. Min. 15. pl. i. fig. 6.
 "Orthoceras minimum," etc. Gaultieri. 1742. Index Test. pl. xix, fig. L.
Nautilus raphanus Linné. 1767. Syst. Nat. 12th ed. 1164, 283; 1788. Ibid. 13th (Gmelin's) ed. 3372. No. 16.

- "*Orthoceratia seu tubuli*" Soldani. 1791. Testaceographia. i. pt. 2. 91. pl. xciv. figs. T, V.
- Nautilus costatus* Montagu. 1803. Test. Brit. 199. pl. xiv. fig. 5.
- Nautilus costatus*, var. Montagu. 1808. Test. Brit. Suppl. 83. pl. xix. fig. 2.
- Orthocera raphanus* Lamarck. 1822. Anim. sans Vert. vii. 593. No. 1; Tabl. Encycl. et Méth. pl. cccclxv. fig. 2. a, b, c.
- Nodosaria scalaris* d'Orbigny. 1826. Ann. Sci. Nat. vii. 253. No. 18.
- Nodosaria rapa* Id. Ibid. 253. No. 27.
- Nodosaria obscura* Reuss. 1845. Verstein. böhm. Kreid. pt. 1. 26. pl. xiii. figs. 7-9.
- Nodosaria bolli* Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellschaft. vii. 265. pl. viii. fig. 6.
- Nodosaria propinqua* Costa. 1856. Atti dell' Accad. Pont. vii. 151. pl. xiii. fig. 2.
- Nodosaria turgidula* Costa. 1856. Atti dell' Accad. Pont. vii. 152. pl. xiii. fig. 3.
- Nodosaria raphanus* Parker and Jones. 1859. Ann. and Mag. Nat. Hist. ser. 3. iii. 477.
- Dentalina pulchra* Gabb. 1860. Jour Acad. Sci. Phila. n. s. iv. 402. pl. lxix. figs. 40, 41.
- Nodosaria bactroides* Reuss. 1862. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 37. pl. ii. fig. 5.
- Nodosaria lamelloso-costata* Id. Ibid. 38. pl. ii. fig. 6.
- Nodosaria prismatica* Id. Ibid. 36. pl. ii. fig. 7.
- Nodosaria raphanus* Silvestri. 1872. Nodos. Foss. e Viv. d'Ital. 43. pl. iv. figs. 67-81.
- Phonemus (Dentalina) pulcher* Meek. 1864. Smithsonian Inst. Mis. Coll. 177. p. 1. 1868. Appendix A. Geology of New Jersey. 721.
- Nodosaria raphanus* Jones, Parker, and Brady. 1866. Monograph. Foram. of the Crag 49. pl. i. figs. 4, 5, 22, 23.
- Nodosaria obscura* Reuss. 1874. Das Elbthalgebirge in Sachsen. pt. ii. 81. pl. xx. fig. 14.
- Nodosaria raphanus* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 512. pl. lxiv. figs 6-10.

Shell straight, subcylindrical, tapering, composed of a few large

ish chambers, and externally ribbed from end to end by stout parallel ridges. The constrictions marking the septal lines are sometimes concealed by overgrowing longitudinal costæ. Liable to become either curved or compressed, or both, with more or less eccentric aperture.

Locality. Timber Creek, in the teredo bed. Rare.

NODOSARIA RAPHANISTRUM Linné, sp.

Nautilus raphanistrum Linn. 1758. Syst. Nat. 10th ed. 710.

No. 242; 1767. 12th ed. 1163. No. 282.

Orthocera raphanistrum Lamarck. 1822. An. s. Vert. 594. No. 3.

Nodosaria bacillum Defrance. 1825. Dict. Sci. Nat. xxxv. 127; xxvi. 487; Atlas Conch. 13. fig. 4.

Nodosaria zippei Reuss. 1844. Kreidegebirg. 210; 1845. Verst. böhm. Kreid. i. 25. pl. viii. figs. 1-3.

Nodosaria bacillum d'Orbigny. 1846. For. Foss. Vien. 40. pl. i. figs. 40-47.

Nodosaria raphanus Parker and Jones. 1860. Quart. Journ. Geol. Soc. xvi. 453. pl. xix. fig. 10.

Nodasaria spectrum Reuss. 1862. Sitzungsab. Akad. Wien. Math. Nat. Cl. xlv. 37. pl. ii. fig. 3.

Nodosaria biformis, *N. bactridium* Reuss. 1866. Denks. Akad. Wien. xxv. 14. pl. i. figs. 23-25.

Nodosaria raphanistrum Jones, Parker, and Brady. 1866. Foram. of the Crag. 50. pl. i. figs. 6-8.

Nodosaria raphanistrum Sherborn and Chapman. 1886. Journ. Roy. Mic. Soc. ser. 2. vi. 749. pl. xiv. fig. 37.

Test long, straight, cylindrical, many chambered; septa more or less constricted; surface ornamented by numerous stout parallel ribs running from end to end of the shell.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Also at Timber Creek, yellow limestone. Rare. Gryphæa bed. Rare.

NODOSARIA SCALARIS Batsch, sp.

"*Orthocerata striata microscopica*" Soldani. 1780. Saggio Oritt. 107. pl. v. figs. L, A, B, C, D; pl. viii. fig. CC.

"*Orthoceratia flosculi*" Soldani. 1791. Testaceographia. i. pt. 2. 91. pl. xcv. figs. B-M.

- "*Polymorphia pineiformia*" Soldani. 1791. Ibid. 118. pl. cxxvii. fig. C.
- Nautilus (Orthoceras) scalaris* Batsch. 1791. Conchyl. des Seesandes. No. 4. pl. ii. fig. 4. a, b.*
- Nodosaria longicauda* d'Orbigny. 1826. Ann. Sci. Nat. vii. 254. No. 28.
- Nodosaria sulcata* Id. Ibid. 253. No. 21.
- Nodosaria candeï* d'Orbigny. 1839. Foram. Cuba. 44 pl. i. figs. 6, 7.
- Nodosaria striaticollis* d'Orbigny. 1839. Foram. Canaries. 124 pl. i. figs. 2-4.
- Lagena williamsoni* (?) Harvey and Bailey. 1853. Proc. Acad. Phila. vi. 431.
- Nodosaria tenuicostata* Costa. 1856. Atti dell' Accad. Pont. vii. 156. pl. xii. fig. 5; pl. xvi. figs. 8-13.
- Nodosaria reussi* Id. Ibid. 155. pl. xvi. fig. 5.
- Nodosaria annulata* Costa. 1857. Mém. Accad. Sci. Nap. ii. 139. pl. i. fig. 16.
- Nodosaria radícula* Williamson. 1858. Rec. Foram. Gt. Br. 15. pl. ii. figs. 36-38.
- Nodosaria scalaris* Parker and Jones. 1865. Phil. Trans. clv. 340. pl. xvi. fig. 2. a, b, c.
- Nodosaria subradícula* Schwager. 1866. Novara Exped. geol. ii. 222. pl. v. fig. 50.
- Nodosaria longicauda* Silvestri. 1872. Nodos. Foss. e Viv. d'Ital. 58. pl. v. figs. 101-127.
- Nodosaria scalaris* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 510. pl. lxiii. figs. 28-31; var. pl. lxiv. figs. 16-19.

"Test is straight; the segments comparatively few, generally from three to six in the adult shell and never more than eight, inflated or subglobular, and increasing rapidly, though not always regularly, in size. The final chamber is drawn out into an apertural tube of some length with a terminal phialine lip, and the opposite extremity of the test is commonly mucronate. The superficial costæ vary both as to number and thickness, and are frequently more numerous and less strongly marked than shown by the figures."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell

layers of the green marl. Frequent. Timber Creek, in the yellow limestone. Quite rare.

NODOSARIA (D.) SOLUTA Reuss.

- Dentalina oligostegia* Reuss. 1850. Haidinger's Naturw. Abhandl. iv. 25. pl. ii. fig. 10.
Dentalina lilli Id. Ibid. 25. pl. ii. fig. 11.
Dentalina soluta Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 60. pl. iii. fig. 4. a, b.
Dentalina globifera Reuss. 1855. Sitzungsab. d. K. Ak. Wiss. Wien. xviii. 223. pl. i. fig. 3.
Nodosaria soluta Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 322. pl. xii. fig. 12.
Dentalina globuligera Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. Wien. xii. 81. pl. ii. fig. 10.
Nodosaria ovularis Costa. 1857. Mem. Accad. Sci. Napoli. ii. 141. pl. i. figs. 8, 9.
Dentalina distincta Reuss. 1860. Sitzungsab. d. K. Akad. Wiss. Wien. xl. 184. pl. ii. fig. 5.
Dentalina catenula Id. Ibid. 185. pl. iii. fig. 6.
Dentalina discrepans Id. Ibid. 184. pl. iii. fig. 7.
Dentalina soluta Stache. 1864. Novara Exped. geol. i. Paläont. 203. pl. xii. fig. 29.
Nodosaria (D.) grandis Reuss. 1865. Denkschr. d. K. Akad. Wiss. Wien. xxv. 131. pl. i. figs. 26-28.
Nodosaria (D.) soluta Id. Ibid. 131. pl. ii. figs. 4-8.
Nodosaria (D.) guttifera Parker and Jones. 1865. Phil. Trans. clv. 343. pl. xiii. fig. 11.
Dentalina soluta Hantken. 1875. Mitth. Jahrb. d. K. ung. geol. Anstalt. iv. 29. pl. ii. figs. 2, 14.
Nodosaria (D.) soluta Brady. 1884. Report on Forams. H. M. S. Challenger. Zool. ix. 503. pl. lxii. figs. 13-16; pl. lxiv. fig. 28.

Test elongate, a little arcuate, with a few spherical chambers; with constricted interstices, first chamber somewhat mucronate, the last produced into a short siphon; aperture naked.

Locality. Timber Creek, in the yellow limestone. Rare. Teredo bed. Frequent.

NODOSARIA VERTEBRALIS Batsch, sp.

Nautilus (Orthoceras) vertebralis Batsch. 1791. Conchyl. des Seesandes. 3. No. 6. pl. ii. fig. 6. a, b.

Nodosaria fascia Parker, Jones, and Brady. 1865. Ann. and Mag. Nat. Hist. ser. 3. xv. 227. No. vi.

Nodosaria vertebralis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 514. pl. lxiii. fig. 35 ; pl. lxiv. figs. 11-14.

"The shell of *Nodosaria vertebralis* is long, slender, slightly tapering, and generally more or less curved ; the segments are very numerous and the septal lines straight ; and the surface is marked by distinct, continuous, longitudinal striæ or riblets. The outline is even and the sutures are unconstricted ; the septa are conspicuously thick and formed of transparent shell substance, but not limbate externally."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, teredo bed. Not abundant.

LINGULINA d'Orbigny.

LINGULINA CARINATA d'Orbigny.

Lingulina carinata d'Orbigny. 1826. Ann. Sci. Nat. vii. 257. No. 1 ; Modèle. No. 26.

Lingulina carinata d'Orbigny. 1839. Foram. Canaries. 124. pl. i. figs. 5, 6.

Lingulina carinata Williamson. 1858. Rec. Foram. Gt. Br. 14. pl. ii. figs. 33-35.

Lingulina carinata Parker and Jones. 1860. Foram. Chellast. Quart. Journ. Geol. Soc. xvi. pl. xix. figs. 13, 14.

Fronicularia nysti Reuss. 1863. Crag. d'Anvers Bull. Acad. Belg. ser. 2. xv. 148. pl. ii. fig. 20.

Lingulina bursæformis Gümbel. 1868. Nordalp. Eocän. K. Bayr. Akad. Abhandl. I. x. 628. pl. i. fig. 51.

Lingulina pygmæa Reuss. 1873. Geinitz' Elbthalgeb. Sachsen. 2. 90. II. 20. fig. 23.

Lingulina glabra Hantken. 1875. Mitth. Jahrbuch. d. K. ungar. geol. Anstalt. iv. 42. pl. xiii. fig. 14.

Nodosarina carinata Goës. 1882. Kongl. Svenska Vet. Akad. xix. pl. i. figs. 65-67.

Lingulina carinata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 517. pl. lxx. figs. 16, 17.

Test oblong-elongate, compressed, carinate, shining, smooth, translucent, anteriorly rotund, posteriorly cuneate, with numerous inequal chambers; aperture linear, transverse.

Locality. Timber Creek, teredo bed. Rare. Gryphæa bed. Rare.

FRONDICULARIA Defrance.

FRONDICULARIA ALATA d'Orbigny.

“*Nautili caudiformes*” Soldani. 1798. Testaceographia. ii. 13. pl. i. fig. C.

Fron dicularia alata d'Orbigny. 1826. Ann. Sci. Nat. vii. 256. No. 2.

Fron dicularia alata Parker, Jones, and Brady. 1871. Ann. and Mag. Nat. Hist. ser. 4. viii. 161. pl. x. fig. 66.

Fron dicularia alata, var. *sagittula* Vanden Broeck. 1876. Ann. Soc. Belg. Micr. ii. 113. pl. ii. figs. 12, 14.

Fron dicularia alata, var. *lanccolata* Id. Ibid. 117. pl. ii. fig. 13.

Fron dicularia complanata, var. *concinna* Id. Ibid. 109. pl. iii. fig. 2.

Fron dicularia alata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 522. pl. lxx. figs. 20-23; var. pl. lxxi. figs. 3-5.

“The figure in the Testaceographia, selected by d'Orbigny to bear the name *Fron dicularia alata*, is that of a short complanate shell, which is very broad near the initial end, owing to the arms of the V-shaped segments reaching back nearly into a line with the primordial chamber. The free ends of the segments are irregular, and most of them projecting and pointed. The drawing is somewhat rough, but represents in their extreme development characters easily recognized in more typical specimens.

“Referring to the illustrations, the two large figures (figs. 20, 21) represent good examples of the species in the adult condition, the free ends of the chambers forming a nearly straight line, and one here and there extended into a projecting point. Such shells attain large dimensions, the length sometimes exceeding one-fifth inch (5 mm.). Vanden Broeck (*loc. cit.*) gives an ex-

cellent series of drawings, representing individual modifications of the species rather than distinct varieties."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill. Frequent. Timber Creek, teredo bed. Rare. Gryphæa bed. Rare. Yellow limestone. Rare.

FRONDICULARIA ANGUSTA Nilsson, sp.

Planularia angusta Nilsson. 1827. Petrifacta Suecana. 11. pl. ix. fig. 22.

Fronidicularia angustata Roemer. 1827. Petrifacta Suecana. 96.

Fronidicularia angusta Reuss. 1844. Geog. Skizzen. aus Böh. ii. 211.

Fronidicularia angusta Geinitz. 1844. Geog. Skizzen. aus Böh. ii. 70. pl. xvii. fig. 22.

Fronidicularia angusta Reuss. 1845. Versteinerungen der böh. Kreid. 20. pl. viii. figs. 13, 14.

"Test 2-6'" elongate, small, lancet-shaped, at the lower end much elongated, above pointed, broadest at or above the centre. From the centre out to the marginal borders decreasing. Numerous (15-25) very small chambers, which are separated by proportionally broad roof-shaped sloping edges. These are interrupted in the centre by a longitudinal furrow which is smaller below, and moreover striated by more fine short lateral furrows, which nevertheless are not continued into the spaces between the edges. The lowest chamber very small, quite spherical, on every side provided with thin sharp longitudinal ribs and a short point on the base. "The tolerably sharp lateral margin is continued over the first chamber to the end of the shell."—Reuss, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Bruere's pits, Crosswick's Creek, lower marl bed, above the gray layer. Rare. Timber Creek, in the teredo bed. Quite rare.

MARGINULINA d'Orbigny.

MARGINULINA COSTATA Batsch, sp.

Nautilus (Orthoceras) costatus Batsch. 1791. Conchyl. des Seesandes. 2. pl. i. fig. 1. a-g.

"*Orthoceratia*, *Raphanus*, *Raphanistrum* et *Rapistrum*" Soldani.

1791. Testaceographia. i. pt. 2. 91. pl. xciv. figs. N, P, Q, R, X, Y.
- Marginulina raphanus* d'Orbigny. 1826. Ann. Sci. Nat. vii. 258. No. 1. pl. x. figs. 7, 8; Modèle. No. 6.
- Marginulina interamnie* Costa. 1856. Atti dell' Accad. Pont. vii. 184. pl. xiii. fig. 9.
- Marginulina obliquestriata* Karrer. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 446. pl. i. fig. 8.
- Marginulina striatocostata* Reuss. 1862. Ibid. xlv. 62. pl. vi. fig. 2.
- Marginulina turgida* Id. Ibid. 63. pl. vi. fig. 7.
- Marginulina raphanus* Parker, Jones, and Brady. 1865. Ann. Mag. Nat. Hist. ser. 3. xvi. 19. pl. i. fig. 35.
- Marginulina hamus* Terquem. 1866. For. du Lias. 6ième mém. 501. pl. xxi. fig. 8. a, b.
- Marginulina radiata* Id. Ibid. 505. pl. xxi. figs. 16, 17.
- Marginulina*, var. *crebica* Seguenza. 1880. Atti R. Accad. dei Lincei. ser. 3. vi. 90. pl. ix. fig. 6.
- Marginulina costata* Brady. 1884. Report on For. H. M. S. Challenger. Zool. ix. 528. pl. lxxv. figs. 10-13.

Test elongate, cylindrical, the chambers or members separated from each other like balls, but are connected by strong ribs, which unbrokenly extend over the entire shell and for the most part have a rectilinear back.

Locality. Timber Creek, teredo bed. Rare.

VAGINULINA d'Orbigny.

VAGINULINA LEGUMEN Linné, sp.

- Nautilus legumen* Linné. 1758. Syst. Nat. 10th ed. 711. No. 248; 1767. 12th ed. 1164. No. 288.
- Nautilus (Orthoceras) leguminiformis* Batsch. 1791. Conchyl. des Seesandes. No. 8. pl. iii. fig. 8. a.
- Vaginulina legumen* d'Orbigny. 1826. Ann. Sci. Nat. vii. 257. No. 2.
- Vaginulina lævigata* Roemer. 1838. Neues Jahrb. für Min. etc. 383. pl. iii. fig. 11.
- Vaginulina elongata* Roemer. 1840. Verst. Nordd. Kreid. 96. pl. xv. fig. 13.

Nodosaria legumen Reuss. 1845. Verst. böhm. Kreid. part 1. 28. pl. xiii. figs. 23, 24.

Dentalina legumen Williamson. 1858. Rect. Foram. Gt. Br. 21. pl. ii. fig. 45.

Vaginulina legumen Jones, Parker, and Brady. 1866. Monogr. Foram. Crag. 64. pl. iv. fig. 9.

Vaginulina legumen Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 530. pl. lxvi. figs. 13-15.

Test smooth, sometimes straight, often arcuate, and sometimes considerably so; slightly compressed laterally; consisting of a linear series of flat, smooth, oblique segments, rarely exceeding twelve in number. Primordial segment abruptly truncate; sometimes cuneiform; occasionally prolonged into a large, solid, transparent mucro. Peripheral outline entire, and not lobulated; though sometimes having the ultimate segment ventricose, and separated from the rest by a deeply constricted septal line. Septal lines smooth, oblique; tending backwards as they approach the convex margin of the shell. Septal aperture at the extremity of the ultimate segment, which extremity is not central, but at the concave margin; surrounded by a well-defined coronal.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

VAGINULINA LINEARIS Montagu, sp.

Nautilus linearis Montagu. 1808. Test. Brit. Suppl. 87. pl. xxx. fig. 9.

Marginulina vaginella Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 152. pl. viii. fig. 2.

Vaginulina striata Costa. 1856. Atti dell' Accad. Pont. vii. 182. pl. xvi. fig. 17.

Dentalina legumen, var. *linearis* Williamson. 1858. Rect. Foram. Gt. Br. 23. pl. ii. figs. 46-48.

Vaginulina linearis Parker and Jones. 1865. Phil. Trans. clv. 343. xiii. figs. 12, 13.

Vaginulina linearis Jones, Parker, and Brady. 1866. Monograph of the Foram. of the Crag. 67. pl. i. figs. 10-12.

Vaginulina eocæna Gümbel. 1868. Abhand. d. K. bayer. Akad. d. Wiss. II. Cl. x. 632. pl. i. fig. 48. a, b.

Cristellaria dilute-striata Id. Ibid. 639. pl. i. fig. 69.

Vaginulina linearis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 532. pl. lxvii. figs. 10-12.

Test straight or bent, more or less compressed ; chambers compactly set on, more or less oval in section ; ornamented in a variable degree with delicate parallel riblets, mostly oblique to axis of the shell ; aperture eccentric.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. New Egypt, in the lower green marl. Fragments. Bruere's pits, Crosswick's Creek, lower marl bed, above the gray layers. Rare.

CRISTELLARIA Lamarek.

CRISTELLARIA ACUTAURICULARIS Fichtel and Moll, sp.

"*Hammonia subrotundæ*," etc. Soldani. 1789. Testaceographia. i. pt. 1. 61. pl. xlix. fig. x.

Nautilus acutaauricularis Fichtel and Moll. 1803. Test. Micr. 102. pl. xviii. figs. g-i.

Cristellaria navicula d'Orbigny. 1840. Mém. Soc. géol. France. iv. 27. pl. ii. figs. 19, 20.

Cristellaria polita Reuss. 1855. Sitzungsab. d. K. Akad. Wiss. Wien. xviii. 237. pl. iii. fig. 41.

Robulina limbata (pars) Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 335. pl. xv. figs. 4, 5.

Cristellaria acutaauricularis Parker and Jones. 1860. Ann. and Mag. Nat. Hist. ser. 3. v. 114. No. 20.

Cristellaria acutaauricularis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 543. pl. cxiv. fig. 17. a, b.

Test spiral, involute, suboval, smooth, ventricose, exumbilicate, keel acute carinate ; convolutions with ten conspicuous subelevated joints ; dissepiments moderately convex in front, oval plane ovate-convex, marginate, with the exterior angle compressed, obtuse, subincurvate ; with orifice in the extremity of the said angle minutely rotund.

Locality. Timber Creek, in the gryphæa bed. Rare.

CRISTELLARIA ARTICULATA Reuss.

Robulina articulata Reuss. 1863. Sitzungsab. d. K. Akad. Wiss. Wien. xlviii. 53. pl. v. fig. 62.

Cristellaria articulata Id. 1870. Ibid. lxii. 483; Schlicht. 1870. Foram. Pietzpuhl. pl. xvii. figs. 5-12.

Cristellaria articulata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 547. lxix. figs. 10-12; wild-growing forms. figs. 1-4.

Test quite circular, slightly angular, compressed, in the centre slightly beaked, with six to eight curved chambers of which the last are moderately broadly triangular, considerably arched, separated by deep sutures, the septal walls of the last chamber oval, deeply outlined on the base, slightly convex.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Timber Creek, teredo bed. Rare.

CRISTELLARIA CREPIDULA Fichtel and Moll, sp.

Nautilus crepidula Fichtel and Moll. 1803. Test. Micr. 107. pl. xix. figs. g-i.

Cristellaria crepidula d'Orbigny. 1839. Foram. Cuba. 64. pl. viii. figs. 17, 18.

Cristellaria berthelotiana d'Orbigny. 1839. Foram. Canaries. 125. pl. i. figs. 14, 15.

Cristellaria intermedia Reuss. 1845. Verstein. böhm. Kreid. pt. i. 33, 108. pl. xiii. figs. 57, 58; pt. ii. pl. xxiv. figs. 50, 51.

Cristellaria cymboides d'Orbigny. 1846. Foram. Foss. Vien. 85. pl. iii. figs. 30, 31.

Cristellaria intermedia Alth. 1850. Haidinger's Naturw. Abhandl. iii. 267. pl. xiii. fig. 23.

Cristellaria jugleri Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 89. pl. iv. fig. 19. a, b.

Cristellaria subarcuatula Williamson. 1858. Rect. Foram. Gt. Br. 29. pl. ii. figs. 56, 57.

Cristellaria intermedia Reuss, var. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 328. pl. viii. fig. 2.

Cristellaria grata Reuss. 1862. Sitzungsab. d. K. Akad. Wiss. Wien. xlvi. 70. pl. vii. fig. 14.

- Cristellaria planiuscula* Id. Ibid. 71. pl. vii. fig. 15.
Cristellaria cordiformis Terquem. 1863. Foram. du Lias. 3^{ième} mém. 203. pl. ix. fig. 14. a, b.
Cristellaria acuminata Id. Ibid. 210. pl. x. fig. 5. a, b.
Hemirobulina compressa Stache. 1864. Novara Exped. i. Paläont. 229. pl. xxiii. fig. 8. a, b.
Cristellaria crepidula Parker and Jones. 1865. Phil. Trans. clv. 344. pl. xiii. figs. 15, 16; pl. xvi. fig. 4.
Cristellaria kochi Reuss. 1866. Denkschr. d. K. Akad. Wiss. Wien. xxv. 139. pl. ii. fig. 35. a, b.
Cristellaria galeata Id. Ibid. 141. pl. iii. fig. 8. a, b.
Cristellaria crepidula Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 542. pl. lxvii. figs. 17, 19, 20; pl. lxviii. figs. 1, 2.

Test spiral subinvolute, elongate, slightly curved, smooth, pellucid, compressed, with subelevated sides, back obtuse, 12-13 conspicuous chambers, planate except the last which is more elevated; chamber walls slightly convex anteriorly, radiating from a common centre with the last two or three, scarcely elevate plane-oval lanceolate convex; orifice minute rotund slightly crenate on the outside of the angle.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

CRISTELLARIA CULTRATA Montfort, sp.

- "*Cornu Hammonis*" Plancus. 1760. Conch. Min. ed. altera-120. pl. i. fig. xii. sec. 552.
 "*Nautili (Lenticulæ marginatæ)*" Soldani. 1789. Testaceographia. i. pt. 1. 54. pl. xxxiii. figs. B etc.
Robulus cultratus Montfort. 1808. Conchyl. Systèm. i. 214 54^e genre.
Robulina cultrata d'Orbigny. * 1826. Ann. Sci. Nat. vii. 287. No. 1; Modèle No. 82.
Robulina canariensis d'Orbigny. 1839. Foram. Canaries. 127. pl. iii. figs. 3, 4.
Robulina subcultrata d'Orbigny. 1839. Foram. Amér. Mérid. 26. pl. v. figs. 19, 20.
Robulina cultrata d'Orbigny. 1846. Foram. Foss. Vien. 96. pl. iv. figs. 10-13.

- Robulina similis* d'Orbigny. Ibid. 98. pl. iv. figs. 14, 15.
Cristellaria hoffmanni Ehrenberg. 1854. Mikrogeologie. pl. xxvi. fig. 53.
Robulina limbosa Reuss. 1863. Sitzungsab. d. K. Akad. Wiss. Wien. xlviii. 55. pl. vi. fig. 69.
Cristellaria gyroscalprum Stache. 1864. Novara Exped. geol. i. Paläont. 243. pl. xxiii. fig. 22. a, b.
Robulina cultrata, var. *antipodum* Id. Ibid. 251. pl. xxiii. fig. 30. a, b.
Robulina tectovata Id. Ibid. 253. pl. xxiii. fig. 32. a, b.
Cristellaria cultrata Parker and Jones. 1865. Phil. Trans. clv. 344. pl. xiii. figs. 17, 18; pl. xvi. fig. 5.
Robulina curvispira Seguenza. 1879. Atti R. Accad. dei Lincei. ser. 3. vi. 144. pl. xiii. fig. 28.
Robulina stellata Id. Ibid. 144. pl. xiii. fig. 29.
Robulina dubia Id. Ibid. 144. pl. xiii. fig. 30.
Cristellaria cultrata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 550. pl. lxx. figs. 4, 5, 6, 7, 8.
Cristellaria cultrata Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 114.

Test orbicular-convex, smooth, or radiate, costate, carinate margin, lamellose; with eight oblique chambers, somewhat convex, smooth or costate, with the last excavated above, aperture radiate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Bruere's pit, Crosswick's Creek, lower marl bed above the gray layers. Not common. New Egypt, green marl. Fragments. Timber Creek, teredo bed. Common. Marlborough, green marl. Quite abundant.

CRISTELLARIA GIBBA d'Orbigny.

- Cristellaria gibbia* d'Orbigny. 1839. Foram. Cuba. 63. pl. vii. figs. 20, 21.
Cristellaria excisa Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 328. pl. xiii. figs. 19, 20.
Cristellaria nuda Reuss. 1861. Sitzungsab. d. K. Ak. Wiss. Wien. xlv. 328. pl. vi. figs. 1-3.
Cristellaria pulchella Id. 1862. Ibid. xlv. 71. pl. viii. fig. 1.

Robulina concinna Id. 1863. Ibid. xlviii. 52. pl. v. fig. 58.

Cristellaria gibba Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 546. pl. lxix. figs. 8, 9.

Test oblong-convex, inflated, subcarinate, smooth, shining, yellowish; ten elongate chambers, arcuate, terminal one subconcave above, margined, with sutures complanate, umbilicus impressed; aperture marginate, radiate.

Locality. Stratton's mari pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Timber Creek, teredo bed. Quite rare. Gryphæa bed. Rare.

CRISTELLARIA ITALICA Defrance, sp.

Saracenaria italica Defrance. 1824. Dict. Sci. Nat. xxxii. 177; xlvii. 344. Atlas Conch. pl. xiii. fig. 6.

Saracenaria italica Blainville. 1825. Man. de Malacol. 370. pl. v. fig. 6.

Cristellaria (*Saracenaria*) *italica* d'Orbigny. 1826. Ann. Sci. Nat. vii. 293. No. 26. Modèles Nos. 19 and 85.

Frondicularia triedra Costa. 1856. Atti dell' Accad. Pont. vii. 174. pl. xiii. figs. 26, 27.

Cristellaria italica Parker, Jones, and Brady. 1865. Ann. and Mag. Nat. Hist. ser. 3. xvi. 22, 32. pl. i. figs. 41, 42.

Cristellaria (*Marginulina*) *italica*, var. *cincta* Karrer. 1877. Geol. K. F.-J. Wasserleitung. 383. pl. xvi. b. fig. 38.

Cristellaria (*Marginulina*) *italica*, var. *aureola* Id. Ibid. 383. pl. xvi. b. fig. 39.

Cristellaria italica Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 544. pl. lxviii. figs. 17, 18, 20-23.

“*Saracenaria*. Shell almost microscopical, oval, celled, with a sort of sinuous keel in its middle, from which start oblique striæ, indications of interior partitions, not sinuous, which divide its cavity into two ranges of chambers; no trace of an exterior opening.”—D’Blainville. 370. pl. v. fig. 6.

“The test of *Cristellaria italica* is elongate and trihedral; the planospiral segments are few and inconspicuous, whilst those of the body of the shell are superimposed so as to form a curved line. The convex or dorsal margin is sharp but not carinate, and the ventral face is so broad that the transverse section of the shell

has the form of a nearly equilateral triangle. The segments are short and obliquely set, dipping at the front more or less towards the initial end, as in *Vaginulina*."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

This being such a peculiar species I have given the original generic description and specific characters given by my esteemed friend, H. B. Brady.

CRISTELLARIA ROTULATA Lamarck, sp.

'Cornu Hammonis seu Nautili' Plancus. 1739. Conch. Minn. 13. pl. i. fig. III.

Lenticulites rotulata Lamarck. 1804. Ann. du Muséum. v. 188. No. 3; Tableau Encycl. et Méth. pl. cccclxvi fig. 5.

Robulina muensteri Roemer. 1841. Verstein. norddeutsch. Kreid. pt. 2. 98. pl. xv. fig. 30.

Cristellaria rotulata Forbes. 1845. Quart. Journ. Geol. Soc. i. 65, 66. fig.

Robulina simplex d'Orbigny. 1846. Foram. Foss. Vien. 102. pl. iv. figs. 27, 28.

Robulina stellifera Czjzek. 1847. Haidinger's Naturw. Abhandl. ii. 142. pl. xii. figs. 26, 27.

Robulina trigonostoma Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 69. pl. iv. fig. 26.

Robulina neglecta Id. Ibid. 69. pl. iv. fig. 27.

Robulina deformis (pars) Bornemann. 1855. Ibid. vii. 337. pl. xiv. fig. 1.

Robulina depauperata Id. Ibid. 337. pl. xiv. fig. 11.

Robulina incompta (?) Id. Ibid. 336. pl. xiv. fig. 12.

Cristellaria calcar (typica) Williamson. 1858. Rec. Foram. Gt. Br. 27. pl. ii. figs. 52, 53.

Cristellaria rotulata Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 326, 336.

Phonemus (*Cristellaria*) *rotulatus* (d'Orbigny ?) Meek. 1864. Smithsonian Inst. Mis. Coll. 177. i.

Cristellaria rotulata Parker and Jones. 1865. Phil. Trans. clv. 345. pl. xiii. fig. 19.

Cristellaria inornata Terquem. 1876. Anim. sur la Plage de Dunkerque. 70. pl. vii. fig. 18.

- Cristellaria austriaca* Id. Ibid. 70. pl. vii. fig. 20. a, b.
Cristellaria simplex Id. Ibid. 70. pl. vii. fig. 21. a, b.
Robulina simplicissima Seguenza. 1879. Atti R. Accad. dei Lincei. ser. 3. vi. 141. pl. xiii. fig. 18.
Robulina lucida Id. Ibid. 142. pl. xiii. fig. 19.
Cristellaria falcifer Stache. 1864. Novara Exped. geol. i. Paläont. 240. pl. xxiii. fig. 19 a, b.
Cristellaria rotulata Schlumberger. 1882. Journ. Cin. Soc. Nat. Hist. v. 119 pl. v. figs. 2, 2a.
Cristellaria rotulata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 547. lxxix. fig. 13. a, b.

Test orbiculate, convex, smooth, non-costate sutures forming a star in the plane centre, without central disc, margin narrowly carinate; nine triangular narrow complanate chambers; aperture radiate

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Very common. Timber Creek, in the yellow limestone. Abundant. Teredo bed. Not abundant.

CRISTELLARIA WETHERELLII Jones, sp.

- Marginulina* sp. Sowerby. 1834. Trans. Geol. Soc. Lond. ser. 2. v. 135. pl. ix. fig. 12.
Marginulina wetherellii Jones. 1854. Morris's Cat. Brit. Foss. 37.
Marginulina wetherellii Parker and Jones. 1859. Ann. and Mag. Nat. Hist. ser. 3. iv. 350.
Marginulina fragaria Gümbel. 1868. Abhandl. d. K. bayer. Akad. d. Wiss. II. cl. x. 635. pl. i. fig. 58. a, b, c.
Cristellaria asperula Id. Ibid. pl. i. fig. 65. a, b.
Cristellaria arcuata Hantken. 1875. Mittheil. Jahrb. d. K. ung. geol. Anstalt. iv. 51. pl. v. fig. 10.
Cristellaria fragaria Id. Ibid. 53. pl. vi. figs. 1-3.
Cristellaria wetherellii Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 537. pl. cxiv. fig. 14.

"The test of *Cristellaria wetherellii* is usually pod-like or crosier-shaped, but varies greatly in length and in the relative development of the spiral and linear portions. It is, however, always more or less spiral at the commencement, and almost invariably exhibits considerable lateral compression; therefore, so

far as such characters are of any distinctive value, it belongs to the genus *Cristellaria* rather than to *Marginulina*. The salient feature of the species is its peculiar surface-decoration, consisting of closely-set raised tubercles, which take the place of continuous limbate septal lines. These are often, but not invariably, connected by slight, oblique, longitudinal costæ, most apparent on the earlier portions of the shell."—Brady. loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Timber Creek, teredo bed. Abundant.

Sub-family POLYMORPHININÆ

POLYMORPHINA d'Orbigny.

POLYMORPHINA ANGUSTA Egger.

Polymorphina (*Globulina*) *fusiformis* Roemer. 1838. Neues Jahrb. für Min. 386. pl. iii. fig. 37.

Polymorphina liassica Strickland. 1845. Quart. Journ. Geol. Soc. ii. 30. fig. b.

Globulina leopolitana Reuss. 1850. Haidinger's Abhandl. iv. 44. pl. v. fig. 11.

Grammostomum turis Ehrenberg. 1854. Mikrogeologie. pl. xxvi. fig. 19.

Globulina acuta Reuss. 1855. Sitzungs b. d. K. Akad. Wissensch. xviii. 51. pl. vi. fig. 62.

Polymorphina (*Globulina*) *angusta* Egger. 1857. Neues Jahrb. für Min. 290. pl. xiii. figs. 13, 15.

Polymorphina subrhombica Reuss. 1861. Sitzungs b. d. K. Akad. Wiss. Wien. xlv. 339. pl. vii. fig. 3.

Polymorphina lanceolata (pars) Reuss. 1870. Sitzungs b. d. K. Akad. Wiss. Wien. lxii. 487. No. 12; Schlicht. 1870. Foram. Pietzpubl. pl. xxxi. figs. 2, 3, 4.

Polymorphina gracilis Id. Ibid. Schlicht. 1870. Foram. Pietzpubl. 486. No. 7. pl. xxxi. figs. 34, 45.

Polymorphina fusiformis (pars) Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 219. pl. xxxix. fig. 5. a, b, c.

Polymorphina angusta Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 563. pl. lxxi. figs. 1-3.

Test elongate, subcylindrical, tapering at both extremities.

Chambers few, from three to four, oblique, somewhat convex, septal lines but slightly depressed. Surface smooth.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

POLYMORPHINA COMMUNIS d'Orbigny.

Polymorphina (*Guttulina*) *communis* d'Orbigny. 1826. Ann. Sci. Nat. vii. 226. No. 15. pl. 12. figs. 1-4; Modèle No 62.

Guttulina vitrea d'Orbigny. 1839. Foram. Cuba. 128. pl. ii. figs. 1-3

Polymorphina (*Guttulina*) *communis* Roemer. 1838. Neues Jahrb. für Min. Jahr. 1838. 385. pl. iii. fig. 29.

Polymorphina glomerata Roemer. 1841. Verstein. norddeutsch. Kreid. pt. 2. 19. pl. xv. fig. 19.

Polymorphina glomerata Reuss 1845. Verstein. böhm. Kreid. pt. 1. 40. pl. xii. fig. 32.

Guttulina communis Reuss. 1845. In Geinitz's Grundriss der Verstein. 669. pl. xxiv. fig. 82.

Guttulina communis d'Orbigny. 1846. Foram. Foss. Vien. 224. pl. xiii. figs. 6-8.

Guttulina irregularis d'Orbigny. Id. Ibid. 226. pl. xiii. figs. 9, 10.

Globulina discreta Reuss. 1849. Denkschr. Mathem-Natur. Cl. K. Akad. Wissensch. i. 378. pl. xlviii. fig. 10.

Guttulina cretacea Alth. 1849. Haidinger's Abhandl. iii. 262. pl. xiii. fig. 14.

Guttulina semiplana Reuss. 1851. Deutsch. d. geol. Gesell. iii. 82. pl. vi. fig. 48

Guttulina semiplana Bornemann 1855. Zeitsch. deutsch. geol. Gesell. vii. 344.

Polymorphina (*Guttulina*) *communis* Egger. 1857. Neues Jahrb. für Min. Jahr. 1857. 288. pl. xiii. figs. 16-18.

Polymorphina (*Guttulina*) *lata* Egger. Ibid. 228. pl. xiii. figs. 22-24.

Guttulina fissurata Stache. 1865. Novara Exped. Geol. i. pt. 2. 263. pl. xxiv. fig. 10.

Guttulina obliquata Id. Ibid. 264. pl. xxiv. fig. 11.

Polymorphina problema, var. *deltoidea* Reuss. 1866. Denkschr. d. mathem. Natur. Cl. Akad. Wiss. xxv. 154. pl. iv. fig. 8.

Polymorphina semiplana Reuss. 1870. Sitzungsab. d. K. Akad. Wiss. Wien. lxii. 488 No. 16; Schlicht. 1870. Foram. Pietz-puhl. pl. xxvii. figs. 22-33.

Polymorphina problema, var. *communis* Id. Ibid. 487. No. 15; Schlicht. pl. xxx. figs. 13-16.

Polymorphina communis Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 224. pl. xxxix. fig. 10. a, b.

Polymorphina communis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 568. pl. lxxii. fig. 19.

Test ovate, gibbous, more or less compressed at three sides; anterior extremity acute; posterior obtuse and rounded. Chambers few, oblique, inflated. Sutures depressed. Surface smooth. Aperture circular, coronate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Rare. Teredo bed. Abundant. In the gryphæa bed. Rare.

POLYMORPHINA COMPRESSA d'Orbigny.

Fistulose form.

Polymorpha corcula spinosa Soldani. 1791. Testaceographia ac Zoophytographia. i. pt. 2. pls. 109-111.

Guttulina damacornis Reuss. 1845. Verst. böhm. Kreid. 1^{te} Abtheil. 40. pl. xiii. fig. 85.

Guttulina tubulosa d'Orbigny. 1846. Foram. Foss. Vien. 228. pl. xiii figs. 15, 16.

Aulostomella pediculus Alth. 1849. Haidinger's Naturw. Abhandl. iii. 264. pl. xiii. fig. 17.

Globulina horrida Reuss. 1850. Ibid. iv. 43. pl. iv. fig. 8.

Polymorphina fistulosa Williamson. 1858. Rec. Foram. Gt. Brit. 72. pl. vi. fig. 150.

Polymorphina lactea, var. *tubulosa* Parker and Jones. 1865. Phil. Trans. Roy. Soc. clv. 362. pl. xiii. fig. 52. a-d.

Polymorphina orbignii (pars) Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 244. pl. xlii. fig. 38. d.

Polymorphina compressa (Fistulose form) Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 566. pl. lxxiii. fig. 17.

Polymorphina compressa Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 114.

Test free or adherent. General form variable; oval, oblong, or compressed. Terminal segments developing numerous irregular expansions and tubular outgrowths.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Quite rare.

POLYMORPHINA LACTEA Walker and Jacob, sp.

“*Serpula tenuis ovalis lavis*” Walker and Boys. 1784. Test. Min. 2. pl. i. fig. 5.

Serpula lactea Walker and Jacob. 1798 (fide Kanmacher). Adams' Essays. 2d ed. 634. pl. xxiv. fig. 4.

Vermiculum lacteum Montagu. 1803. Test. Brit. 522.

Guttulina plancii d'Orbigny. 1839. Voyage dans l'Amér. Mérid. 60. pl. i. fig. 5.

Polymorphina lactea Macgillivray. 1843. Moll. Aberd. 320.

Archusa lactea Thorpe. 1844. Brit. Mar. Conch. 233.

Globulina lachryma Reuss. 1845. Verstein. böhm. Kreid. pt. 1. 40, 110. pl. xiii. fig. 83; Alth. 1849. Haidinger's Abhandl. iii. 263. pl. xiii. fig. 16; Reuss. 1850. Ibid. iv. 43. pl. v. fig. 9.

Pyrulina ovulum Ehrenberg. 1854. Mikrogeologie. pl. xxxi. figs. 35, 36.

Polymorphina muensteri Reuss. 1855. Sitzungsab. d. K. Akad. Wiss. Wien. xviii. 249. pl. viii. fig. 80.

Globulina rocmeyeri Id. Ibid. 245. pl. vi. fig. 63.

Polymorphina lactea, typica (pars) Williamson. 1858. Rec. Foram. Gt. Brit. 71. pl. vi. fig. 147.

Polymorphina lactea, var. communis Id. Ibid. 72. pl. vi. figs. 153-155.

Polymorphina lactea Dawson. 1859. Can. Nat. and Geologist. iv. 28. figs. 2, 3.

Guttulina diluta Bornemann. 1860. Zeitschr. deutsch. geol. Gesellsch. xii. 160. pl. vi. fig. 11.

Globulina lacrima Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 318, 338.

Polymorphina lactea Brady, Parker, and Jones. 1870. (Mono-

graph of *Polymorphina*) Trans. Linn. Soc. Lond. xxvii. 213. pl. xxxix. fig. 1. a-c.

Polymorphina lactea Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 559. pl. lxxi. (typical) fig. 11; (var.) fig. 14.

Polymorphina lactea Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 114.

Fistulose form.

"*Polymorpha corcula spinosa*" Soldani. 1791. Testaceographia. i. pt. 2. 114. pl. cix. fig. I, etc.

Misilus aquatifer Montfort. 1808. Conch. Systém. i. 294. 74^e genre.

Apiopterina d'Orbigni Zborzewski. 1834. Nouv. Mém. Soc. Imp. Nat. Moscou. iii. 311. pl. xxviii. fig. 2. b.

Polomorphina lactea (fistulose form) Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 560. pl. lxxiii. fig. 14.

Test ovate, gibbous, slightly unsymmetrical; anterior extremity acute; posterior obtuse, rounded. Chambers few, oblong, oblique, somewhat inflated. Sutures depressed. Surface smooth. Aperture simple, circular or oval, radiate.

Locality. Timber Creek, in the yellow limestone. Rare. Teredo bed. Quite abundant.

The fistulose forms are those having a hollow, like a pipe or reed. They are occasionally found in the teredo bed.

POLYMORPHINA OBLONGA d'Orbigny.

Polymorphina oblonga d'Orbigny. 1846. Foram. Foss. Vien. 232. pl. xxii. figs. 29-31.

Polymorphina uvæformis Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 289. fig. 5.

Polymorphina guttata Reuss. 1870. Sitzungsab. d. K. Akad. Wiss. Wien. lxii. 487; Schlicht. 1870. Foram. Pietzpuhl. pl. xxx. figs. 25-32.

Polymorphina oblonga Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 569. pl. lxxiii. figs. 2-4.

Test elongate, smooth, anteriorly acuminate, posteriorly obtuse, compressed; with six oblong chambers, convex; sutures excavate, aperture radiate.

Locality. Timber Creek, in the teredo bed. Rare.

POLYMORPHINA PROBLEMA d'Orbigny.

Polymorphina (Guttulina) problema d'Orbigny. 1826. Ann. Sci. Nat. vii. 266. No. 14; Modèle No. 61.

Polymorphina (Guttulina) crassatina Münster. 1838 (fide Roemer). Neues Jahrb. für Min. Jahr. 1838. 385. pl. iii. fig. 30.

Polymorphina (Guttulina) spicæformis Roemer. 1838. Ibid. 386. pl. iii. fig. 31.

Guttulina problema Reuss. 1845. In Geinitz's Grundriss der Verstein. 669. pl. xxiv. fig. 83.

Guttulina problema d'Orbigny. 1846. Foram. Foss. Vien. 224. pl. xii. figs. 26-28.

Guttulina austriaca Id. Ibid. 223. pl. xii. figs. 23-25.

Guttulina cretacea Alth. 1849. Haidinger's Naturw. Abhandl. iii. 262. pl. xiii. fig. 14.

Polymorphina uvula Ehrenberg. 1854. Mikrogeologie. pl. xxvi. fig. 28.

Polymorphina uvula Egger. 1857. Neues Jahrb. für Min. Jahr. 1857. 285. pl. x. figs. 26-29.

Guttulina cretacea Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 319, 339.

Guttulina rotundata Reuss. 1864. Sitzungsab. d. K. Akad. Wiss. Wien. l. 469. pl. iii. fig. 4.

Guttulina pusilla Stache. 1865. Novara Exped. Geol. i. pt. 2. 265. pl. xxiv. fig. 12.

Polymorphina problema Parker, Jones, and Brady. 1866. Monogr. Crag Foram. pl. i. fig. 64.

Polymorphina problema Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 225. pl. xxxix. fig. 11. a, b.

Polymorphina problema Brady. 1884. Report Foram. H. M. S. Challenger. Zool. ix. 568. pl. lxxii. fig. 20; pl. lxxiii. fig. 1.

Test oblong, ovate, irregular. Chambers numerous, much inflated, and separated by deep sutures; sometimes arranged tri-serially, but more frequently crowded together irregularly; orifice round, radiate; surface smooth.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the teredo bed. Abundant.

POLYMORPHINA REGULARIS von Münster.

- Polymorphina regularis* von Münster. 1838 (fide Roemer). Neues Jahrb. für Min. Jahr. 1838. 385. pl. 3. fig. 21.
- Polymorphina regularis* Philippi. 1844. Beiträge zur Kenntniss d. Tertiärverst. nordwest. Deutsch. 41, 70.
- Polymorphina regularis* Karsten. 1849. Verzeichn. d. Rostock. Verst. a. d. Sternberger Gestein. 8.
- Polymorphina regularis* Reuss. 1855. Sitzungsber. d. K. Akad. Wiss. Wien. xviii. 247. pl. vii. figs. 70-73; l. 38. pl. iii. figs. 11, 12. pl. iv. fig. i.
- Polymorphina regularis*, var. *Nysti* Reuss. 1863. Bullet. de l'Acad. roy. de Belgique. xv. 162. pl. iii. fig. 42.
- Polymorphina lingulata* Stache. 1865. Novara Reise i. 2^{te} Abtheil. Paläont. von Neu-Seeland. 255. pl. 24. fig. i.
- Polymorphina marsupium* Stache. 1865. Novara Reise. i. 2^{te} Abtheil. Paläont. von Neu-Seeland. 258. pl. xxiv. fig. 5.
- Polymorphina dispar* Stache. 1865. Novara Reise. i. 2^{te} Abtheil. Paläont. von Neu-Seeland. 261. pl. xxiv. fig. 8.
- Polymorphina gigantea* Stache. 1865. Novara Reise. i. 2^{te} Abtheil. Paläont. von Neu-Seeland. 262. pl. xxiv. fig. 9.
- Polymorphina regularis* Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 229. pl. xl. fig. 13. a-c.

Test oblong, irregularly biconvex, broadest in the upper half, tapering towards both base and apex; periphery thin and produced but not carinate. Septal lines marked by slight constriction. Chambers numerous, long, oblique. Surface smooth.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Timber Creek, in the terebratulite bed. Not common.

POLYMORPHINA ROTUNDATA Bornemann, sp.

- Guttulina rotundata* Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 346. pl. xi. p. xviii. fig. 3.
- Guttulina incurva* Id. Ibid. 345. pl. xvii. fig. 6.
- Guttulina fracta* Id. Ibid. 344. pl. xvii. fig. 4.
- Guttulina dimorpha* Id. Ibid. 345. pl. xvii. fig. 5.
- Polymorphina rotunda* Reuss. 1866. Denkschr. mathem. Naturw. Cl. K. Akad. Wissensch. xxv. 153.

- Polymorphina tenera* Karrer. 1868. Sitzungsab. d. K. Akad. Wiss. Wien. lviii. 174. pl. iv. fig. 9.
- Rostrolina* sp. Schlicht. 1870. Foram. Pietzpuhl. 72. No. 412. pl. xxvi. figs. 13-15.
- Polymorphina rotunda* Reuss. 1870. Sitzungsab. d. K. Akad. Wiss. Wien. lxii. 487. No. 14; Schlicht. op. cit. pl. xxvi. figs. 13-15; pl. xxviii. figs. 1-5; pl. xxx. figs. 33-40.
- Polymorphina turgida* Id. Ibid. 487. No. 10; Schlicht. pl. xxviii. figs. 6-10; pl. xxix. figs. 1-5.
- Polymorphina rotundata* Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 234. pl. xl. fig. 19. a-e, and woodcuts.
- Polymorphina rotundata* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 570. pl. lxxiii. figs. 5-8.

Test oblong, ovoid, subcylindrical, gibbous, rounded at the base, more or less produced at the apex. Chambers numerous, broad. Septa marked by lines only, neither constricted nor excavated. Orifice simple, round, oval, or radiate. Surface smooth.

Locality. Timber Creek, in the teredo bed. Rare.

GLOBIGERINIDÆ.

GLOBIGERINA d'Orbigny.

GLOBIGERINA CRETACEA d'Orbigny.

- Globigerina cretacea* d'Orbigny. 1840. Mém. Soc. Geol. France. iv. 34. pl. iii. figs. 12-14.
- Globigerina foveolata* (pars) Ehrenberg. 1854. Mikrogeologie. pl. xxiv. fig. 49.
- Globigerina libani* Ehrenberg. Ibid. pl. xxv. fig. 30.
- Planulina pachyderma* Id. Ibid. pl. xxv. fig. 31.
- Rotalia pertusa* Id. Ibid. pl. xxiv. fig. 41.
- Rotalia aspera* Id. Ibid. pl. xxvii. figs. 57, 58; pl. xxviii. fig. 42; pl. xxxi. fig. 44.
- Rotalia globulosa* Id. Ibid. pl. xxvii. fig. 60; pl. xxviii. figs. 40, 41; pl. xxxi. figs. 40, 41, 43.
- Rotalia densa* Id. Ibid. pl. xxvii. fig. 62.
- Rotalia quaterna* Id. Ibid. pl. xxvii. fig. 53; pl. xxviii. fig. 34.

- Rotalia rosa* Id. Ibid. pl. xxvii. fig. 54.
Rotalia pachyomphala Id. Ibid. pl. xxvii. fig. 55.
Rotalia tracheotetras Id. Ibid. pl. xxvii. fig. 35.
Rotalia perforata Id. Ibid. pl. xxviii. fig. 36; pl. xxix. fig. 2.
Rotalia protacmæa Id. Ibid. pl. xxviii. fig. 37.
Rotalia laxa Id. Ibid. pl. xxviii. fig. 38; pl. xxix. fig. 1; pl. xxxi. fig. 42.
Rotalia centralis Id. Ibid. pl. xxviii. fig. 39.
Globigerina cretacea G. M. Dawson. 1875. Report Geol. and Resources, 49th Parallel British N. A. Boundary Comm. 79.
Globigerina cretacea Brady. 1879. Quart. Journ. Micr. Sci. xix. n. s. 285.
Globigerina cretacea Schwager. 1883. Palæontographica. xli. fig. 13. a-d.
Globigerina cretacea Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 596. pl. lxxxiii. Fossil specimens. fig. 11. a-c.
Globigerina cretacea Woodward and Thomas. 1885. 13th Ann. Report. Geol. Nat. Hist. Survey Minn. 171. pl. iii. figs. 14-16; ii. fig. 19.
Globigerina cretacea Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.
Globigerina cretacea Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 41. pl. D. figs. 18, 19.
 Test suborbicular, compressed, rugose aculeate, spire obtuse, with three distinct convolutions, five to seven segments, depressed spheroidal, sutures excavated, aperture large in the umbilicus.
 Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Timber Creek, in the yellow limestone. Rare. Teredo bed. Common.

ROTALIDÆ.

DISCORBINA Parker and Jones.

DISCORBINA BERTHELOTI d'Orbigny, sp.

- Rosalina bertheloti* d'Orbigny. 1839. Foram. Canaries. 135. pl. i. figs. 28-30.

- Discorbina bertheloti* Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 469. pl. xlviii. fig. 10. a, b.
- Discorbina turbo*, var. *parisiensis*, subvar. *berthelotiana* Parker and Jones. 1865. Phil. Trans. clv. 387. pl. xvi. figs. 26, 27.
- Discorbina berthelotiana* Goës. 1882. Kongl. Sv. Vet. Akad. xix. 107. pl. viii. figs. 266-268.
- Discorbina bertheloti* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 650. pl. lxxxix. figs. 10-12.
- Discorbina bertheloti* Woodward. 1887. Journ. N. Y. Mic. Soc. iii. 17.

Test very depressed, carinate, punctate; spire short, with two convolutions, partly with depressed chambers, carinate, arcuate, margin limbate.

Locality. Timber Creek, in the yellow limestone. Quite rare. Teredo bed. Rare.

TRUNCATULINA d'Orbigny.

TRUNCATULINA HAIDINGERII d'Orbigny, sp.

- Rotalina haidingerii* d'Orbigny. 1846. Foram. Foss. Vien. 154. pl. vii. figs. 7-9.
- Rotalina ehrenbergii* Bailey. 1851. Smithsonian Contrib. ii. art. 3. 10. figs. 11-13.
- Rotalia brueckneri* Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 273. pl. ix. fig. 7.
- Rotalia propinqua* Reuss. 1855. Sitzungsab. d. K. Akad. Wiss. Wien. xviii. 241. pl. iv. fig. 53. a, b, c.
- Rotalia hemisphærica* Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 314. pl. ii. fig. 5.
- Rotalia lenticula* Reuss. 1863. Sitzungsab. d. K. Akad. Wiss. Wien. xlvi. 35. pl. x. fig. 3.
- Planorbulina haidingeri* Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 469. pl. xlviii. fig. 11.
- Planorbulina farcta* var. *haidingerii* Parker and Jones. 1865. Phil. Trans. clv. 382. pl. xvi. fig. 22. a, b.
- Truncatulina haidingeri* Reuss. 1867. Sitzungsab. d. K. Akad. Wiss. Wien. lv. 28.
- Pulvinulina haidingeri* Hantken. 1875. Mittheil. Jahrbuch. d. Kön. ungar. geol. Anstalt. iv. 77. pl. xv. fig. 10. a, b.

Truncatulina haidingerii Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 663. pl. xcv. fig. 7. a-c.

Test orbicular, trochiform, punctate, below somewhat convex, umbilicate, spire conical; with four narrow convolutions, externally carinate, with six chambers arcuate above, below narrowly triangular, convex.

Locality. Timber Creek, in the yellow limestone. Rare.

TRUNCATULINA LOBATULA Walker and Jacob, sp.

"*Nautilus spiralis lobatus*, etc." Walker and Boys. 1784. Test. Min. 20. pl. iii. fig. 71.

"*Hammonia tuberculata*, etc." Soldani. 1789. Testaceographia. i. pt. 1. 58. pl. xlv. figs. ii. kk, ll, mm.

Nautilus lobatulus Walker and Jacob. 1798. Adam's Essays, Kammacher's Ed. 642. pl. xiv. fig. 36.

Serpula lobatula Montagu. 1803. Test. Brit. 515. Suppl. 160.

Truncatulina tuberculata d'Orbigny. 1826. Ann. Sci. Nat. vii. 279. No. 1; Modèle No. 37.

Truncatulina lobatula d'Orbigny. 1839. Foram. Canaries. 134. pl. ii. figs. 22-24.

Discorbis lobatulus Macgillivray. 1843. Moll. Anim. Aberd. 34.

Truncatulina lobatula d'Orbigny. 1846. Foram. Foss. Vien. 168. pl. ix. figs. 18-23.

Truncatulina boveana d'Orbigny. 1846. Foram. Foss. Vien. 169. pl. ix. figs. 24-26.

Anomalina variolaria d'Orbigny. 1846. Foram. Foss. Vien. 170. pl. ix. figs. 27-29.

Truncatulina communis Reuss. 1855. Sitzungsab. d. K. Akad. Wiss. Wien. xviii. 242. pl. v. fig. 56.

Truncatulina lobatula Parker and Jones. 1857. Ann. and Mag. Nat. Hist. ser. 2. xix. 293. pl. x. figs. 17-21.

Truncatulina lobatula Williamson. 1858. Rec. Foram. Gt. Br. 59. pl. v. figs. 121-123.

Truncatulina varians Reuss. 1860. Sitzungsab. d. K. Akad. Wiss. Wien. xlii. 359. pl. ii. fig. 12. a, b.

Truncatulina lobatula Dawson. 1860. Can. Nat. and Geologist. v. 192. fig. 50.

Rotalia polyraphes Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 337.

- Rosalina bosqueti* Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 337. pl. iii. fig. 1.
- Truncatulina dekayi* Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 338. pl. vii. fig. 6. a, b, c.
- Planorbulina farcta*, var. (*Truncatulina*) *lobatula* Parker and Jones. 1865. Phil. Trans. clv. 381. pl. xiv. figs. 3-6 ; pl. xvi. figs. 18-20.
- Truncatulina lobatula* Jones, Parker, and Brady. 1866. Monogr. Foram. Crag. pl. ii. figs. 4-10 ; pl. iv. fig. 18.
- Truncatulina (lobulata ? d'Orb.)* Hilgard and Hopkins. 1878. Reclamation of the Alluvial Basin of the Miss. River. 43. pl. ii. fig. 65.
- Truncatulina lobatula* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 660. pl. xcii. fig. 10 ; pl. xciii. figs. 1, 4, 5 ; pl. cxv. figs. 4, 5.
- Truncatulina lobatula* Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 115.

Test suborbiculate, depressed, slightly punctate, beneath somewhat convex ; with three convolutions, externally angular ; with seven chambers, arcuate above, irregular somewhat convex.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Common. Teredo bed. Common. New Egypt, in the green marl. Rare.

TRUNCATULINA UNGERIANA d'Orbigny, sp.

- Rotalina ungeriana* d'Orbigny. 1846. Foram. Foss. Vien. 157. pl. viii. figs. 16-18.
- Rotalina granosa* Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellschaft. iii. 75. pl. v. fig. 36.
- Rotalina semipunctata* Bailey. 1851. Smithsonian Contrib. ii. art. 3. 11. figs. 17-19.
- Rotalia roemeri* Reuss. 1855. Sitzungsab. d. K. Akad. Wiss. Wien. xviii. 240. pl. iv. fig. 52.
- Rotalia mortoni* Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 337. pl. viii. fig. 1.
- Planorbulina ungeriana* Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 469. pl. xlviii. fig. 12.

Planorbulina farcta, var. *ungeriana* Parker and Jones. 1865.

Phil. Trans. clv. 382. pl. xvi. figs. 23-25.

Truncatulina ungeriana Reuss. 1866. Denkschr. d. K. Akad.

Wiss. Wien. xxv. 161. No. 10.

Truncatulina ungeriana Brady. 1884. Report on Foram. H.

M. S. Challenger. Zool. ix. 664. pl. xciv. fig. 9. a, b, c.

Test orbicular, depressed, punctate, below somewhat convex, umbilicate, spire complanate, granulose, with three wide convolutions, externally acutely carinate; with eleven chambers, above triangular, below flexuose, somewhat convex, externally margined (limbate), the last convex.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone and the teredo bed. Rare.

ANOMALINA d'Orbigny.

ANOMALINA AMMONOIDES Reuss, sp.

Rosalina ammonoides Reuss. 1845. Verstein. böhm. Kreid. pt. 1.36. pl. xiii. fig. 66; pl. viii. fig. 53.

Rosalina ammonoides Reuss. 1850. Haidinger's Naturw. Abhandl. iv. 36. pl. iv. fig. 2.

Rotalia ammonoides Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 337.

Nonionina bathyomphala Reuss. 1862. Sitzungsab. d. K. Akad. Wiss. Wien. xlvi. 95. pl. xiii. fig. 1. a, b.

Rosalina weinkauffi Reuss. 1863. Sitzungsab. d. K. Akad. Wiss. Wien. xlviii. 68. pl. viii. fig. 97.

Rosalina maorica Stache. 1864. Novara Exped. geol. i. 282. pl. xxiv. fig. 32.

Rosalina orbiculus Stache. 1864. Novara Exped. geol. i. 285. pl. xxiv. fig. 34.

Planorbulina ammonoides Parker and Jones. 1865. Phil. Trans. clv. 379.

Rotalia capitata Gümbel. 1868. Abhandl. d. K. bayer. Akad. Wiss. II. cl. x. 653. pl. ii. fig. 92.

Rotalia ammonoides Reuss. 1870. Sitzungsab. d. K. bayer. Akad. Wiss. 283.

Planorbulina (Anomalina) ammonoides Jones and Parker. 1872. Quart. Journ. Geol. Soc. xxviii. 106; table 109.

Planorbulina ammonoides Reuss. 1874. Das Elbthalgebirge in Sachsen. ii. 114. pl. xxiii. fig. 9.

Anomalina ammonoides Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 672. pl. xciv. figs. 2, 3.

Anomalina ammonoides Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.

Anomalina ammonoides Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 44. pl. D. figs. 28, 29, 30.

“The nautiloid aspect of the test is perhaps a more constant and more noticeable feature of *Anomalina ammonoides* than of any other member of the group. The shell is generally much compressed, and nearly equally convex on the two sides; the peripheral edge is round, and the aperture is placed almost symmetrically in the median line. In certain characters, however, the species betrays a tendency to variation. Some specimens are depressed at both umbilici (fig. 3), others are umbonate at one or both (fig. 2); sometimes the earlier convolutions are visible to a nearly equal extent on both faces; sometimes, on the other hand, they are nearly involute on the inferior side, though the shell retains its bilateral symmetry, as in Reuss’s figure. The coarse perforation of the shell-wall is usually more conspicuous on the inferior than on the superior face.”—Brady, loc. cit.

Locality. Bruere’s pits, Crosswick’s Creek, lower marl bed, in the gray marl. Rare. Timber Creek, in the teredo bed. Quite abundant.

PULVINULINA Parker and Jones.

PULVINULINA MICHELINIANA d’Orbigny.

Rotalina truncatulinoides d’Orbigny. 1839. Foram. Canaries. 132. pl. ii. figs. 25-27.

Rotalina micheliniana d’Orbigny. 1840. Mém. Soc. géol. France. iv. 31. pl. iii. figs. 1-3.

Rotalina nitida Reuss. 1845. Böhm. Kreide. 1. 35. pl. xii. figs. 8, 20, 31; pl. viii. fig. 52.

Rotalia micheliniana Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 336.

- Discorbina micheliniana* Reuss. 1865. Sitzungsab. d. K. Akad. Wiss. Wien. liii. 455. No. 1.
- Pulvinulina repanda*, var. *menardii*, sub var. *micheliniana* Parker and Jones. 1865. Phil. Trans. clv. 396. pl. xiv. fig. 16; pl. xvi. figs. 41-43.
- Pulvinulina micheliniana* Owen. 1867. Journ. Linn. Soc. Lond. ix. Zool. 148. pl. v. fig. 17.
- Pulvinulina normanni* Karrer. 1878. For. Luzon. Bolet. Comis. Mapa geol. d. España. 7. 2, 24. pl. F. fig. 10.
- Pulvinulina micheliniana* Brady. 1879. Quart. Journ. Micr. Sci. xix. n. s. 80.
- Pulvinulina micheliniana* Goës. 1882. Königl. Sv. Vet. Akad. xix. 114. pl. viii. figs. 296-298.
- Pulvinulina micheliniana* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 694. pl. civ. figs. 1, 2.

Test orbicular convex, smooth, above plane, beneath convex-conical, margin carinate, spire complanate, with three convolutions, feebly distinct; with angular chambers, subcomplanate, umbilicus convex, aperture elongate.

Locality. Timber Creek, in the yellow limestone. Rare.

PULVINULINA KARSTENI Reuss, sp.

- Rotalia karsteni* Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellschaft. vii. 273. pl. ix. fig. 6.
- Rotalia karsteni* Reuss. 1861. Sitzungsab. xlv. 337.
- Pulvinulina karsteni* Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 470. pl. xlviii. fig. 15.
- Pulvinulina repanda*, var. *karsteni* Parker and Jones. 1865. Phil. Trans. clv. 396. pl. xiv. figs. 14, 15, 17; pl. xvi. figs. 38-40.
- Pulvinulina karsteni* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 698. pl. cv. figs. 8, 9.
- Pulvinulina karsteni* Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 115.

"The test of *Pulvinulina karsteni*, in well-developed specimens, is nearly round and very regularly built, convex on both faces, and with obtuse subangular periphery. It is composed of from three to four convolutions, the final circuit having about seven chambers; the sutures, which are marked by fine lines on

the superior face, are somewhat depressed on the inferior ; and the margin of the test on the inferior side has a limbate border." —Brady, loc. cit.

Locality. Timber Creek, in the yellow limestone. Common. Teredo bed. Not common.

ROTALIA Lamarck.

ROTALIA ORBICULARIS d'Orbigny.

Rotalia (Gyroidina) orbicularis d'Orbigny. 1826. Ann. Sci. Nat. vii. 278. No. 1 ; Modèle No. 13.

Rotalia orbicularis Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 470. pl. xlviii. fig. 16.

Rotalia beccarii, var. *orbicularis* Parker and Jones. 1865. Phil. Trans. clv. 389. pl. xvi. fig. 34.

Rotalia orbicularis Terquem. 1882. Mém. Soc. géol. France. ser. 3. ii. Mém. III. 60. pl. iv. figs. 1-3.

Rotalia orbicularis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 706. pl. cvii. fig. 5 ; pl. cxv. fig. 6.

"The test of *Rotalia orbicularis* is approximately plano-convex, the superior face being flat or only slightly arched, the inferior convex and more or less excavated at the umbilicus, and the peripheral edge subangular. It is isomorphous with *Truncatulina lobatula* in the Planorboline series, and forms a connecting link between *Rotalia beccarii* and *Rotalia soldanii*.—Brady, loc. cit."

Locality. Timber Creek, in the yellow limestone. Rare. Teredo bed. *Quite common.

NUMMULINIDÆ.

Sub-Family NUMMULITINÆ.

OPERCULINA d'Orbigny.

OPERCULINA COMPLANATA, var. GRANULOSA Leymerie.

Amphistegina fleuriauxi d'Orbigny. 1826. Ann. Sci. Nat. vii. 304. No. 7. (name only, fide Reuss).

Operculina granulosa Leymerie. 1846. Mém. Soc. géol. France. ser. 2. i. 359. pl. xiii. fig. 12. a, b.

Amphistegina fleuriauxi Reuss. 1861. Sitzungsab. d. K. Akad. Wiss. Wien. xlv. 308. pl. i. figs. 10-12.

Operculina irregularis Reuss. 1864. Denkschr. d. K. Acad. Wiss. Wien. xxiii. 10. pl. i. figs. 17, 18.

Operculina granulata Gümbel. 1868. Abhandl. d. K. bayer. Akad. d. Wiss. II. Cl. x. 663. pl. ii. fig. 111. a, b.

Operculina complanata, var. *granulosa* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 743. pl. cxii. figs. 6, 7, 9, 10.

Operculina complanata, var. *granulosa* Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 176. pl. ii. fig. 36.

Operculina complanata, var. *granulosa* Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 46. pl. E. fig. 38.

Test. It is uniformly smaller than *complanata*; its partitions, which form a slight relief upon the surface of the very thin shell which encloses the convolutions, are proportionally more approximate. This species is very flat, and is made up of three or four spirals. It carries on its surface on each side a number of fine granulations, which are found irregularly distributed upon the little elevations which correspond to the interior partitions. These projecting points, scarce upon the last convolutions, are found crowded towards the centre in many individuals.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. New Egypt, in the green marl. Rare.

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